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LEVEL II

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HUMAN AND PHYSICAL FACTORS AFFECTING COLLISIONS, RAMMINGS, AND GROUNDINGS ON WESTERN RIVERS AND GULF INTRACOASTAL WATERWAYS

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FINAL REPORT

JANUARY 1979

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16. Abstract

This report is the result of a study of accident data involving towboat-barge configurations on the Western Rivers and the Gulf Intercoastal Waterway. The study was done to identify "any consistent patterns of casual factors...(and to) gain further insights into the extent that human factors are involved in towing vessel collisions, rammings, and groundings."

The study examined all collisions, rammings, and groundings on the waterways that were reported to the Coast Guard during FY 1972-FY1976 and involved at least one towing vessel and barge. The study examined in depth all accidents located in ten mile segments where there were at least ten accidents during the study period. Navigational charts, traffic density, and monthly river discharge data was obtained for each segment under study. The analysis compared the frequencies of vessel, personnel, and environmental characteristics for accidents grouped by waterway, type of navigational situation in the accident site, and type of accident. The physical factors were interpreted with respect to task performance requirements identified in previous Coast Guard sponsored research.

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Eighty-six percent of the vessel control accidents that were reported during the study period occured on five waterways: the Upper Mississippi River, the Illinois Waterway, the Ohio, the Lower Mississippi, and the Gulf Intracoastal Waterway. The majority of the accidents occured within 35 10-mile segments, or about 10% of the total navigable distance. These waterways had one or more of the following environmental characteristics: one or more bridges; one or more locks; both a lock and a bridge; a bend, intersection, or junction; or a very narrow available channel width. Other environmental factors of cause included current and current effects, wind, submerged hazards, low water, and "mud lumps". The majority of the river accidents occured on downriver passages, with accidents at bridges on the rivers occuring during high water. The majority of the collision accidents occured on the GIWW. The majority of these collisions occured at intersections and junctions.

Average tow length was 3 to 13 barges over all waterways and other accident groupings. Other 'vessel' characteristics that affected the study included: physical constraints, and vessel power (as a function of load size).

The casual factors cited in the studied accident reports pointed overwhelmingly to environmental factors as being one of, if not the major factor. Except in collision reports, task performance failures were raley identified as casual factors. Task performance problems in rammings and groundings were found to be imprecise and untimely indentification or estimation of current force and direction, and imprecise and untimely estimation of current effects on the tow. If he had the information it is impossible to predict the response characteristics of the vessel characteristics of the vessel configuration.

TECHNICAL REPORT NO. 1456
VOLUME I OF 2

HUMAN AND PHYSICAL FACTORS AFFECTING COLLISIONS, RAMMINGS, AND GROUNDINGS ON WESTERN RIVERS AND GULF INTRACOASTAL WATERWAYS

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We would also like to acknowledge the gracious cooperation of members of the towing industry. We cannot name each individual captain, pilot, and operations manager who gave time to talk with study team members by telephone and in person about hazards and problems in towboat navigation. We would like, at least, to credit the organizations involved for the contributions of their personnel to safety research, and for authorizing those contributions to be made. Thanks to:

- Dixie Carriers, Inc.
- Ohio Barge Line, Inc.
- Missouri Barge Line

- National Marine Services, Inc.
- Southern Towing.

Members of the marine insurance industry as well assisted the study effort by providing accident cost data enabling us to assess the difference between actual costs and those estimated during accident investigations. We are grateful in this regard to:

- American Marine Underwriters, Inc.
- Neare Gibbs and Company
- U.S. Salvage Association
- The Travelers Insurance Company
- Marine Office of America.

In addition, we are grateful to personnel from the U.S. Army Corps of Engineers and the National Oceanographic and Atmospheric Administration who provided the study with information about waterway traffic and flow rates.

Finally, ORI would like to acknowledge the excellent work done by Mr. Robert B. Dayton, as study consultant, and by subcontractor ECO, Inc., in particular, Mr. Joseph D. Porricelli and Mr. Richard M. Willis.

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EXECUTIVE SUMMARY

DESCRIPTION OF THE STUDY

Scope and Objectives (See Section I, pages 1 and 2)

This study examined data on accidents involving towboat-barge configurations on the Western Rivers and the Gulf Intracoastal Waterway. The contractual objectives were to identify "any consistent patterns of causal factors...[and to] gain further insights about the extent that human factors are involved in towing vessel collisions, rammings and groundings." (Statement of Work, page 3)

The study population included all collisions, rammings and groundings on the above waterways that were reported to the Coast Guard during FY 1972 - FY 1976 and involved at least one towing vessel and barge. The cases in the population were identified by obtaining listings from the Coast Guard's Automated Vessel Casualty Data File.

Accident Sample (See Section I, pages 4-12, and Section III, pages 28-30)

The first phase of the analysis was to determine the distribution of accidents over the waterways and time period of the study. The accidents were found to be dispersed in time, but significant clusters were seen with respect to location. Thus a location-based sample was used, including all 10-mile segments in which a minimum of 10 accidents were reported during the study period. (The criterion for the GIWW was a minimum of 15 accidents because of a generally higher accident frequency.)

Data Sources and Data Development (See Section II)

The major data source was the body of casualty investigation reports compiled and maintained by U.S. Coast Guard Headquarters. Included are the forms CG-2692, Marine Casualty Investigation Report, and CG-4724, Towing Addendum. The 4724 was not available in all cases since its use was discontinued in FY 1976. All supplementary materials appended to the forms were also used. These forms and attachments provided information about certain vessel, personnel, and environmental characteristics as well as conclusions from the investigations as to accident causes.

The navigational charts of the sample segments were obtained so that the precise accident locations could be related to physical features of the environment.

Data for estimating traffic density in the study segments were obtained from the Department of the Army Corps of Engineers. These data were used to evaluate the accident rates and to assure that the clustering of accidents previously mentioned was not simply a function of variations in traffic density.

Monthly river discharge rates were also obtained so that the relationship between accident frequency and water stage might be explored. The river discharge data were obtained from the National Oceanographic and Atmospheric Administration.

Finally, damage costs for each accident in the population were compiled by year from the Automated Marine Casualty Data File listings. These data reflect the severity of the accidents. Data were obtained from insurers on the actual costs to date of a sample of accidents, so that the accuracy of the estimates made in preparing the accident reports might be assessed.

The accident data base for analysis was developed as follows:

1. A questionnaire was written for the purpose of systematically surveying the accident cases. (See Appendix B) Each case was read and the information coded for computer manipulation.

2. The location of each accident was plotted on a navigational chart of the area. Notations were made as to the direction of transit and the causal factors cited in the reports. (See Appendix C.)

3. An indicator of traffic density was computed for each segment of all waterways in the sample. Graphs were prepared relating traffic density to accident frequency over each waterway. (See Appendix A.)

4. Monthly river discharge rates were plotted over histograms of monthly numbers of accidents. (See Section III, pages 38-49.)

5. Histograms were prepared of the annual costs of damage to vessels, cargo and property. (See Section III, pages 94-102.)

<u>Analysis Procedure</u> (See Section I, page 13.)

The analysis compared the frequencies of vessel, personnel and environmental characteristics for accidents grouped by waterway, type of navigational situation in the particular accident sites, and type of accident. Measures of central tendency were computed for continuous variables. Frequently recurring accident characteristics were evaluated for potential causal significance in light of known characteristics of towboat operations in general.

The causal inferences contained in the accident reports were compiled and analyzed separately. The causal factors were interpreted in relation to the task performance requirements of towboat control as identified in previous research for the Coast Guard. This was done in an effort to clarify the nature of human errors as contributers to accident occurrence. The causal factors were also interpreted in relation to the findings of fact about vessel, personnel, and environmental characteristics.

Towboat captains and pilots, and operations managers of towboat companies were asked for their opinions as to principal accident causes and to describe the hazards of operation in the waterway segments that were studied. Their views were compared to study findings and conclusions. Consistency was taken as an indicator of the validity of the study results. Differences are pointed out in the report.

MAJOR FINDINGS

Accident Clusters (See Section I, pages 4-12 and Section III, pages 28-30)

Eighty-six percent of the vessel control accidents (collisions, rammings, and groundings) on the Western Rivers and the Gulf Intracoastal Waterway (GIWW) that were reported FY 1972 - FY 1976 occurred on five waterways: the Upper Mississippi River, the Illinois Waterway, the Ohio, the Lower Mississippi and the GIWW. Within those waterways, the major clusters of accidents are seen in 35 10-mile segments, i.e., in about 10% of the total navigable distance. The other accidents tend to be dispersed in time and location.

Fixed Physical Characteristics of Accident Sites (See Section III, pages 30-35)

The waterway segments where accidents tend to occur have in common the following characteristics:

- One or more bridges
- One or more locks
- Both a bridge and a lock
- A bend, intersection or junction
- Very narrow available channel width.

Most of the segments have more than one of these features. In 65% of the accidents at a bridge or lock there was a bend within ½ mile.

Variable Environmental Conditions (See Section III, pages 35-51 and 70-76)

Current was the single most frequently cited causal factor in both rammings and groundings, and it was also frequently cited in the collision reports. Current was cited in 35% of the cases overall. Other causal factors were cited which imply current effects, including, for example, out of alignment, lost control in bend, etc. Wind was cited less frequently, in only 12% of all of the cases. Other environmental conditions mentioned included submerged hazard, low water, "mud lumps"; these were cited in 21% of the

groundings and in less than 5% of the cases within the collisions and rammings. (See Tables 3.15 - 3.17, pages 71, 78, and 82.)

Eighty percent of the accidents on the rivers occurred on downriver passages in which current effects are most strongly felt (Tables 3.4 and 3.5, pages 36 and 37). A tendency was noted for accidents at bridges on the rivers to occur during high water periods (Figures 3.1 - 3.9, pages 41-49). Seventy two percent of the collisions studied occurred on the GIWW West, where current is not a factor except at intersections and junctions; however, about three-fourths of the collisions were found to occur at such locations or at a bend.

<u>Vessel Characteristics</u> (See Section III, pages 52-61)

The tows in the accident cases were not exceptionally large. They averaged from about 3 to 13 barges over all waterways and other accident groupings (Table 3.9). Predictably, accidents at locks typically involved smaller tows than accidents at bridges, since tow dimensions are more limited by lock dimensions. Similarly, the tows in the accidents on the GIWW were quite small, and smaller tows were also evident on the Illinois Waterway. The study data suggest that in many locations, tow dimensions are pushing the limits of the physical constraints (Table 3.11). It is not known if our accident sample differs from the general population in this, but it seems more likely that it does not, given the economic impetus to move as much cargo per trip as possible.

Most of the towboats in the study sample were in the range from above 2500 HP to 5000 HP. This power class is overrepresented in the sample of accident cases by about 20% whereas less powerful boats (2500 HP or less) are underrepresented to a similar extent. This may be the result of excluding smaller rivers from the study (since their accident history was trivial relative to that of the selected waterways). (See Table 3.7 and associated text, pages 52-55.)

The main point about powering is that in relation to loads, the vessels in the study sample of accidents typically were not underpowered if present-day standards in the industry are accepted. (See Tables 3.8 and 3.10 and associated text, pages 56-59).

Causal Factors Cited in the Reports (See Section III, pages 67-82)

The causal factors cited in the accident reports pointed overwhelmingly to environmental factors. As previously noted, current, wind and allusions to those forces were the major recurring factors. Except in the collision reports, deficiencies in task performance by towboat personnel were rarely specified. Nonuse of bridge-to-bridge radiotelephone was the most frequently cited task failure in the collisions (mix-ups in information were also cited). Since most of the collisions occurred at bends, communications failures and failure to detect the other vessel in time overlap (Table 3.15, page 71).

Other major task performance problem areas were inferred by examining the causal factors and situational characteristics in relation to the task requirements for safe tow navigation. The principal task problem areas in rammings and groundings were found to be imprecise or untimely identification or estimation of current force and direction, and imprecise or untimely estimation of current effects on the tow (Section III, pages 77-81). Towboat personnel do not have adequate sources of information of either kind. They apparently made excellent use of their knowledge born of experience, but they acknowledge that anticipation of current effects is always somewhat of a guessing game, which every pilot cannot win every time. As previously noted, there is some question whether available power was sufficient to control the tow in all cases, even if the control decisions had been perfect and the actions perfectly timed.

Another task problem area is in determining available navigation distances, relating structural elements and other obstacles to tow length and breadth and tow position and orientation (as affected by current, wind and water depth).

Environmental features may hinder this task such as, most notably in the accident cases, a bend hiding a structure, obstacle, aid, or shoreline, or such as the poor detectability of concrete bridge supports.

The frequent causal factors and characteristics of the accidents are drawn together in "typical accident scenarios" near the end of Section III

(pages 83-95). These scenarios illustrate the conclusions about major physical and task performance factors. Charts of accident sites are included.

CONCLUSIONS (See Section IV, pages 107-118)

The most general and basic conclusion of this study is that the accidents typically arose from expectable variance in the accuracy and timing of control decisions and actions, in situations in which the safe path had to be defined and adhered to with precision. In all of the typical accident scenarios there was little margin for error. This conclusion is based on (a) the clustering of accidents in locations characterized by certain kinds of hazards and maneuvering constraints and (b) the nature of the causal factors cited in the reports and their implications as to task performance problems.

Physical Hazards and Maneuvering Constraints - Major Physical Factors

The accident potential appears to be greatest when there is a structure or restriction to be negotiated

- on a downriver passage
- when there is a bend above or below
- when there are cross currents and/or cross winds
- during high water periods (for passages through bridges).

Towboat and array characteristics appear to be interactive with the foregoing environmental characteristics in creating a high risk situation. Array dimensions in relation to available maneuvering area appears to be the most significant indicator. The data were insufficient to test this theory thoroughly. However, it was found that in bridge rammings on three of the five waterways array the ratio of bridge span to array breadth ranged from 1.7 to 2.6 and the corresponding ratio in lock rammings was 1.1 to 1.5. In groundings, the ratio of tow length to channel width averaged 1.25 for all waterways; 80% of the groundings took place within ½ mile of a bend.

Questions remain about the adequacy of towboat horsepower, especially in downriver passages through areas including both a bend and a major structure. The measures of horsepower versus load that could be obtained suggested

that horsepower was generally adequate, at least judging by prevalent standards. It is believed, however, that powering requirements should be explored further, in conjunction with the spatial relationships discussed above. Powering does not seem to be the issue in itself (given the horsepower/load findings of this study), but rather the precision necessary in navigational decision-making to utilize the available power effectively against even moderate forces in a highly confined area.

The collision cases were unique in several respects. On the whole, they were not so clearly control-related as the rammings and groundings. The principal environmental factors were the narrowness of the available channel and current at bends and intersections/junctions.

Task Performance Problems - Major Human Factors

It is concluded that the towboat pilot does not have reliable, precise and timely information about the environmental hazards that will be encountered. Moreover, even if he had such information, it is impossible to predict with certitude and precision the response characteristics of the vessel configuration, including tows of variable dimensions and tonnage in channels of different depth, width and contours, with variously located structures and obstacles. Thus, at least some degree of uncertainty and error in control actions would appear to be inevitable until such time as pilots can be provided with better input data and with technological assistance or at least theoretical support in translating those data into control actions.

Pilots are operating intuitively from experience at present. For the most part they are successful. It is possible that their experience gained through normal operations might be enriched through real-time simulator exercises in which they face high-risk situations in repetitive trials, with feedback about vessel performance. Other than that, the only apparent means of reducing accident rates would be to lessen the rigors of the operating environment or to undertake the research and development necessary to provide pilots with better information on which to base control decisions and actions.

It has been pointed out that collisions appear to be an exception category of accidents in that presently available tools might be utilized

more effectively to avoid accidents. In particular, utilization of bridge-to-bridge radiotelephone might be improved by conventional training methods, in combination with clearer guidelines in the regulations.

The use of radar did not emerge as a major task performance factor in any of the three accident types. However, the potential of radar as a navigational aid as well as a collision avoidance aid is not being fully realized. Equipment capabilities and condition need to be examined as well as knowledge of how to utilize radar most effectively. In 37% of the cases studied, the radar either was not on or was not working properly.

It is not clear the extent to which a single operator could rely on radar in a close maneuvering situation. Certainly to do so goes sharply against tradition in inland waters navigation, where direct visual observation of familiar landmarks and water characteristics is the way of life.

RECOMMENDATIONS (See Section IV, pages 118-122)

Recommendations are directed to all major elements of the vessel control process: environment, vessel and equipment, personnel, and procedures. It is urged that environmental improvements be sought, to eliminate hazards, although it is recognized that there are political and economic barriers to waterway modifications. Specific recommendations are highlighted below:

Environmental Improvements

- The Coast Guard should institute a process for assessing the impact of new bridges, in particular, but also all other waterway and waterside facilities, on the movement of marine traffic. The parameters to be considered with respect to bridges include span, location and orientation of the bridge with respect to channel contours and width and current patterns. Movable bridges and bridges at bends should be avoided if at all possible. Present water traffic density and the range of tow dimensions should be considered; expected developments in the number and sizes of tows and in the types of cargo carried should be taken into account.

- The utilization of existing bridges by land traffic should be evaluated. Removal of underutilized bridges should be considered.

- When a bridge or lock is taken out of use, the entire structure should be removed as soon as possible. No submerged structural elements should be left as hazards to navigation.

- The poor detectability of bridge piers should be improved by the use of radar transponders, conical reflectors, or at least by marking with reflective tape.

- The Coast Guard should, in cooperation with the Corps of Engineers, undertake an inventory of hazards to navigation in segments of the inland waterways with a history of frequent accidents. An action plan should be devised for eliminating hazards or protecting water traffic from them. Political, legal, and administrative actions should be specified as well as technical requirements.

<u>Vessel and Equipment Improvements</u>

- Perform the necessary analytical modeling to determine power requirements, taking into account the tow dimensions as well as weight, in relation to the available maneuvering area, spatial relationships and forces acting upon the tow.

- Improve the aids to navigation on approaches to bridges, especially. An innovative system design appears to be needed to allow pilots to line up and maintain alignment with greater accuracy, especially where the bridge approach includes a bend. The utilization of conical reflectors along the shoreline should be investigated. It would also be desirable to investigate the feasibility of an electronic information/guidance system to warn of slide and rotation.

<u>Personnel Training and Procedural Improvements</u>

- Modify the existing Bridge-to-Bridge Radiotelephone Regulations to require the use of broadcast calls in blind situations.

At the same time publish explicit guidance on how to use bridge-to-bridge radiotelephone for collision avoidance. Involve operating personnel in developing such guidance.

- Determine the rate of non-participation in vessel traffic advisory systems. Evaluate the need for nonvoluntary systems to control traffic movement in highly confined areas where accidents, especially collisions have been frequent. (Segments of the GIWW need to be evaluated in particular).

- Explore the feasibility of creating a real-time simulation training capability for towboat navigation on the inland waterways. (The previously recommended analytic study of powering requirements in relation to tow dimensions and environmental variables would serve this effort.)

ACCIDENT RATES, SEVERITY AND THE JUSTIFICATION OF SAFETY ACTIONS (See Section IV, pages 122-123.)

Some final remarks are included concerning the accident rates and costs - they are low compared to other commodity transport modes, which may make it difficult to justify problem-solving actions that require substantial effort. It is observed that many of the accidents studied might have had very severe consequences had there been only minor differences in circumstances.

ORGANIZATION OF THE REPORT

The main body of the report is organized much like this summary. The study scope, objectives, design and methods are described first in Section I. Date sources and data base development procedures are documented in Section II. The detailed results of the analysis are presented in Section III. That section concludes with "typical accident scenarios" which draw together the salient results in generalized illustrative cases. Conclusions and recommendations are presented in Section IV.

There are four appendices to this report containing backup documentation as listed in the Table of Contents. Raw data used in the analysis are stored on magnetic tape.

1. INTRODUCTION

This is a study of factors in towing vessel (towboat-barge configuration) accidents on the Western Rivers and Gulf Intracoastal Waterway. The study describes trends in accident characteristics, including features of the environment in which the accident occurred, atmospheric and water conditions, characteristics of the vessel configuration(s) involved, and operating personnel factors.

The study was performed for the U.S. Coast Guard, Office of Merchant Marine Safety, during the months of March through September 1978. The purpose of the undertaking was to identify and clarify principal safety problems and ways of reducing the likelihood of accidents on the inland waters of the United States.

STUDY SCOPE

A retrospective analysis was performed on accident data covering a 5-year period -- specifically, collisions, rammings and grounding that were reported FY 1972 through 1976 and involved at least one towboat with barges. The collisions that were examined involved two separate vessel configurations, that is, two towboat-barge arrays or a towboat-barge array and some other kind of vessel. A collision of a towboat with a barge in the array being moved by that towboat was excluded. In addition, both vessel configurations must have been underway for the case to be included among the collisions. If one of the vessels/vessel configurations was adrift, the case was treated as a

ramming. The rammings category also (primarily) included collisions of an underway vessel configuration with another vessel anchored or moored, or with a fixed object or aid to navigation (fixed or floating). The groundings category included cases of contact with the waterway such that special maneuvers or assistance were required to get free, with or without damage to vessel.

The accident data were taken from the marine casualty investigation reports which are prepared by U.S. Coast Guard investigators when accidents occur. These reports are then maintained by the Coast Guard as an historical data base. Additional sources of information were used to aid in analyzing the accident-descriptive information contained in the Coast Guard reports. The nature and the sources of the complete set of data used in this study are reviewed in Section II.

SPECIFIC STUDY OBJECTIVES

The statement of work prepared for this study by the Coast Guard defines the objectives as follows:

- To screen reports of towing vessel collision, ramming, and grounding incidents on the Western Rivers and Gulf Intracoastal Waterway for any consistent patterns of causal factors. . .
- To gain further insights about the extent that human factors are involved in towing vessel collisions, rammings, and groundings.

It was desired to relate accident factors indicated in this study to the task requirements of towing vessel pilotage, as defined in a previous study.[1]

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[1] The task analysis of vessel control was completed in December 1976. It was performed to provide a frame of reference for analysis of human factors in vessel collisions, rammings and groundings. The task requirements for effective vessel control are a frame of reference within which the human contribution to control failures may be categorized systematically and situational factors evaluated for their apparent impact on task performance. J. Smith et al., Task Analysis Report Relative to Collisions, Rammings and Groundings, Silver Spring, Maryland: ORI, Inc. December 1976. U.S. Coast Guard Report No. CG-D-1-77; NTIS AD A037316.

BACKGROUND INFORMATION

In 1975, the Coast Guard initiated a study of towboat accidents at bridges because of the increasing frequency of such accidents and the increase in volume of hazardous materials being transported by water.[2] The initial investigation was triggered by recent accidents which damaged barges containing hazardous substances, in light of the potential for disastrous consequences under the right sets of circumstances. The present study is a continuation effort, going beyond the initial problem of accidents at bridges to address towboat accidents on the system in general.

The present study extends another line of research undertaken by the Coast Guard in 1975, the investigation of human factors in vessel control. The thrust of the human factors program has been to clarify the nature of human performance problems in vessel control, to establish the frequency with which specific kinds of human performance problems contribute to accidents, and to establish the circumstances in which these problems tend to occur, so that safety efforts can be programmed more effectively.

The human factors program was prompted by several earlier studies that pinpointed "human error" as the predominant category of accident causal factors.[3]

The first step in the human factors program was to perform an analysis of personnel task requirements for safe vessel control.[4] The results provide a framework for analysis of situations in which vessel control failed. The

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[2] R. B. Dayton, Analysis of Bridge Collision Incidents, Volumes I and II. Silver Spring, Maryland: ORI, Inc., May 1976 and December 1976. NTIS AD A029034 and AD A036732.

[3] W. Dunn and P. Tullier, Spill Risk Analysis, Phase II: Methodology Development and Demonstration. Silver Spring, Maryland: Operations Research, Inc., November 1975. NTIS AD 785 026. Maritime Transportation Research Board, Human Error in Merchant Marine Safety. Washington, D.C.: National Academy of Sciences, June 1976. L. Stoehr et al., Spill Risk Analysis Program: Methodology Development and Demonstration, Volume I. Silver Spring, Maryland: Operations Research, Inc., May 1977. U.S. Coast Guard Report No. CG-D-21-77. NTIS AD A043054. H. Istance and T. Ivergard, "Ergonomics and Reliability in Ship Handling Systems - Theories, Models and Methods." Paper presented at the Fourth Ship Control Symposium, Den Helder, The Netherlands, October 1975.

[4] J. Smith et al., previously cited.

present study of towboat-barge accidents looked for omissions and non-successes in performance of the tasks specified in the earlier study, and also looked at the situational context as thoroughly as possible given available data.

STUDY DESIGN

This study is a descriptive analysis, seeking to identify patterns in the human and physical circumstances observed in accident events. Interpretations of the analysis findings are provided. These interpretations were made by vessel personnel and others with special expertise in maritime operations and safety.

Study Population and Sample

The study population is comprised of accidents. These were sampled on a location basis using a criterion of a minimum number of accidents in the location. The sampling procedures and rationale are explained below.

The total number of accidents in the study population is 2063. The population was defined to include all collisions, rammings, and groundings that were reported FY 1972 through FY 1976, in which the primary vessel was a towing vessel with one or more barges operating on one of the Western Rivers or the Gulf Intracoastal Waterway.

Study of the distribution of accidents showed that the major problem areas were on the Upper and Lower Mississippi, the Ohio River, the Illinois Waterway, and the Gulf Intracoastal Waterway (GIWW) West. Accidents on the other rivers and waterways were infrequent and dispersed both in location and time over the years of the study period. Table 1.1 shows the number of accidents by type on all of the bodies of water under consideration.

Analysis of the accident distributions on the Mississippi, Ohio, Illinois and GIWW showed that problem areas may be narrowed down to a relatively small number of 10-mile segments of those waters. Thirty-five segments were identified in which 10 or more accidents occurred during the study period. These accidents (614) comprise 30% of the total population of accidents as defined above.

TABLE 1.1

ACCIDENTS REPORTED FY 1972 - 76, BY LOCATION AND TYPE*

(Accidents in which the primary vessel was a towboat or barge)

River/Waterway	Accident Type			Total
	Collision	Ramming	Grounding	
Mississippi to Mile 125	75	123	15	213
Mississippi from Mile 125 to Cairo	85	110	90	285
Upper Mississippi	18	178	87	283
Ohio	38	220	88	346
Illinois	20	124	21	165
GIWW West	229	173	71	473
Total	465	928	372	1765
Cumberland	0	10	6	16
Allegheny	0	3	1	4
Monongahela	0	14	2	16
Missouri	0	6	2	8
Kanawa	0	8	2	10
Arkansas	0	5	1	6
Kentucky	0	0	0	0
Tennessee	4	48	33	85
Other rivers	4	23	12	39
GIWW East	27	46	41	114
Total Other	35	163	100	298
Total Accidents	500	1091	472	2063
% Sample to Total	93%	85%	79%	86%

* This table excludes the Gulf Inland Rivers and waterways outside the GIWW itself. There were 106 accidents in those waters.

The 35 segments in which 10 or more accidents occurred were found to have common physical characteristics, including one or more bridges or locks. The Lower Mississippi below mile 125, which takes in the port of New Orleans, was excluded because of differences in vessel mix, hazards, and types of accidents in that area.

With regard to accident type, rammings were found to be most frequent (natures 04, 09, 11 in the USCG Automated Vessel Casualty File coding system). This is consistent with the presence of major structures in the high-frequency segments. Groundings were least frequent. There were 500 collisions (natures 01,02,03,05,06,07) in the study population of accidents. Just under 80% occurred on the GIWW-West (229 collisions) or on the lower Mississippi to to Cairo (160 collisions).

Tables 1.2 - 1.6 show the number of accidents in each segment in which 10 or more accidents occurred. There is a separate table for each body of water, beginning with the Upper Mississippi River in Table 1.2. A comparison of sample accidents to total on each body of water is provided. Table 1.7 shows the number of accidents in segments where there were high accident rates relative to traffic although there were fewer than 10 accidents during the study period. Tables 1.8 and 1.9 provide an overall comparison of the sample to the total population of accidents considered in this study.

Traffic Factor. More accidents may be expected to occur in areas where there is more traffic. Thus a check was made of the accidents distribution, controlling for traffic density. The purpose was to establish whether the high accident frequencies observed in the 35 segments identified for the study sample were essentially a function of traffic (i.e., more opportunities for accidents), or whether it appeared that indeed some other attributes of the operating situation in those areas might be provoking accidents. A synthetic measure was used, developed by the U.S. Army Corps of Engineers for its Inland Navigation System (INS) model. The measure is number of transits during a typical month, where transits are derived from commodity flow data (1975 data were used) assuming that all barges are always loaded to full capacity. This assumption is obviously not necessarily true, and the effect is to underestimate transits. However, traffic has been measured this

TABLE 1.2

SAMPLE OF ACCIDENTS ON THE UPPER MISSISSIPPI RIVER
BY MILE SEGMENT AND TYPE

Mile Segment*	Number of Accidents			
	Collisions	Rammings	Groundings	Total
040	0	2	9	11
050	1	3	17	21
180	0	13	1	14
200	2	15	17	34
270	0	11	0	11
380	0	12	1	13
400	0	13	1	14
Total	3	69	46	118
Total all segments	18	177	139	328
% sample to total	17%	39%	33%	36%

*Mile given is mid-point of 10-mile segment.

TABLE 1.3

SAMPLE OF ACCIDENTS ON THE LOWER MISSISSIPPI RIVER
FROM MILE POINT 125, BY MILE SEGMENT AND TYPE
(Sample inludes those segments in which 10 or more accidents occurred.)

Mile Segment *	Number of Accidents			
	Collisions	Rammings	Groundings	Total
170	6	6		12
220	5	5		10
230	3	16		19
440		9	2	11
530	2	15		17
Total	16	51	2	69
Total all segments	85	110	90	285
% sample to total	19%	46%	2%	24%

*Mile given is mid-point of 10-mile segment.

TABLE 1.4

SAMPLE OF ACCIDENTS ON THE OHIO RIVER
(Sample includes those segments in which 10 or more accidents occurred.)

Mile Segment*	Number of Accidents			
	Collisions	Rammings	Groundings	Total
280	1	15		16
340	1	12		13
600	1	11	5	17
780	1	5	4	10
810	1	6	3	10
840	—	11	—	11
850	1	7	5	13
940	—	10	4	14
980	—	10	—	10
Total	6	87	21	114
Total all segments	38	220	83	346
% sample to total	16%	40%	25%	33%

*Mile given is mid-point of 10-mile segment.

TABLE 1.5

SAMPLE OF ACCIDENTS ON THE ILLINOIS WATERWAY
(Sample includes those segments in which 10 or more accidents occurred.)

Mile Segment*	Number of Accidents			
	Collisions	Rammings	Groundings	Total
040	1	14	2	17
160		21		21
210	1	8	1	10
270		8	4	12
290	1	14	1	16
300	5	11		16
Total	8	76	8	92
Total all segments	20	124	21	165
% sample to total	40%	61%	38%	56%

*Mile given is mid-point of 10-mile segment.

TABLE 1.6

SAMPLE OF ACCIDENTS ON THE GIWW-WEST
(Sample includes those segments in which 15 or more accidents occurred.)

Mile Segment*	Number of Accidents			
	Collisions	Rammings	Groundings	Total
10	4	12	1	17
50	6	11	1	18
60	10	13	3	26
90	12	24	4	40
100	13	9	3	25
110	12	4	—	16
120	17	1	4	22
170	8	5	6	19
240	7	8	4	19
280	8	10	3	21
400	—	14	1	15
Total	97	111	30	238
Total all segments	229	173	71	473
% sample to total	41%	64%	42%	50%

* Mile given is mid-point of 10-mile segment.

TABLE 1.7

SEGMENTS WITH LESS THAN 10 ACCIDENTS
BUT WITH HIGH ACCIDENT/TRAFFIC DENSITY FACTORS

Waterway and Segment*	Number of Accidents			
	Collisions	Rammings	Groundings	Total
Ohio River				
010	—	9	—	9
030	—	8	—	8
050	1	4	3	8
Illinois Waterway				
240	1	6	2	9
Upper Mississippi				
810	—	7	—	7

* Mile given is mid-point of 10-mile segment.

TABLE 1.8

COMPARISON OF SAMPLE ACCIDENTS TO TOTAL ACCIDENTS, BY BODY OF WATER AND ACCIDENT TYPE

	Percentage of Total Accidents Represented by Sample			
Waterway	Collisions	Rammings	Groundings	Total
Lower Mississippi from m.p. 125	19	46	2	24
Upper Mississippi	17	39	33	36
Ohio	16	40	25	33
Illinois	40	61	38	56
GIWW-West	41	64	42	50
Total	26	36	19	30

TABLE 1.9

NUMBER OF SAMPLE ACCIDENTS

Waterway	Collisions	Rammings	Groundings	Total
Lower Mississippi from m.p. 125	16	51	2	69
Upper Mississippi	3	69	29	101
Ohio	8	76	8	92
Illinois	6	87	21	114
GIWW-West	97	111	30	238
Total	130	394	90	614
Total System Accidents	500	1091	472	2063

way for equivalent segments that cover the entire Inland Waterway System. There is no other source of comprehensive, disaggregated traffic data.

The numbers of accidents for all segments were compared to the traffic indicators as illustrated in Figure 1.1. At the top if Figure 1.1 is a graph of the accident rate factor, created by dividing the number of accidents in a segment by the traffic measure, average number of towboat-barge arrays in the port equivalent during a 30-day period. Mile points are marked along the horizontal axis of the accident frequency histogram at the bottom of Figure 1.1.

The contours of the accident rate line at the top and the accident frequency histogram at the bottom of Figure 1.1 are highly similar, showing that differences in the numbers of accidents were not simply a function of the numbers of vessels passing through different areas. The contours of the accident rate line and the traffic activity line just below it show some marked differences.

Figure 1.1 uses the Illinois Waterway as an example. Comparable results were obtained for all waterways (see Appendix A). For all waterways, the results confirmed that the sample segments represented major trouble spots. Several additional segments were identified with low accident frequency (fewer than 10 during the 5-year study period) but a relatively high accident rate (accident/traffic density factor). These were included in the study sample as indicated in the preceding Table 1.7.

Data Development

The data for the analysis were obtained by surveying accident reports. For this purpose a questionnaire was designed, specifying a set of human and physical factors that might influence vessel control performance. The presence or absence of those factors, or, in some cases (e.g., visibility, horsepower) their degree, was documented from the reports. Some data elements (e.g., horsepower, number of propellers, river discharge rates) are not consistently provided in the accident reports but could be obtained from other relatively accessible records.

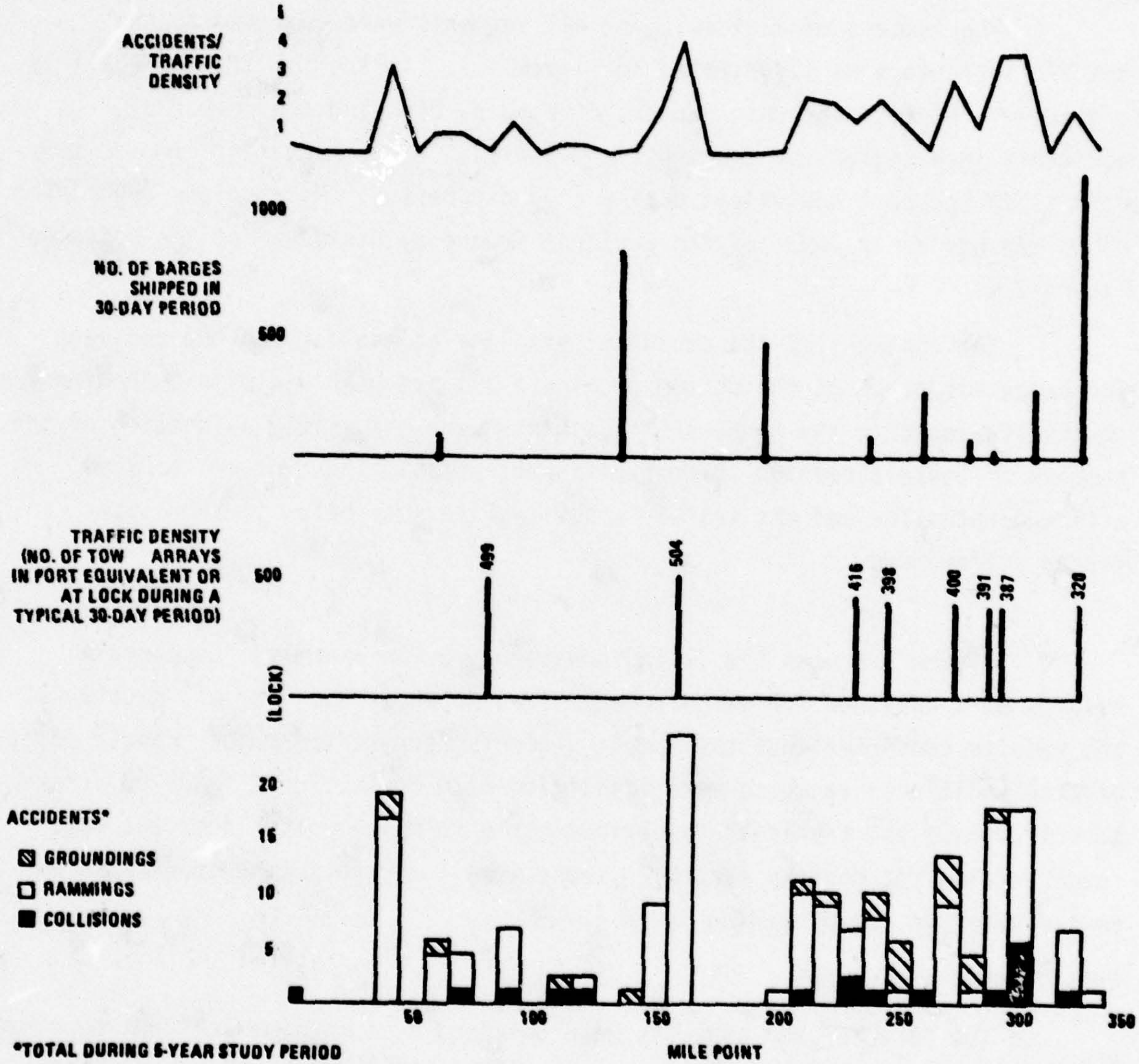

FIGURE 1.1. EXAMPLE RESULTS FROM ANALYSIS OF ACCIDENTS IN RELATION TO TRAFFIC DENSITY

(Example From Illinois Waterway)

Data sources and data development procedures are described in more detail in Section II.

Analytic Approach

The first step of the analysis was to examine the physical attributes of the locations in which the clusters of accidents had been found to occur. Several common characteristics were prominent: the presence of one or more bridges or locks, the presence of one or more bends in the channel, the combination of a bridge or lock and a bend in close proximity. These characteristics were taken to define a grouping variable, "type of navigational situation." The accidents were grouped on that basis and the frequencies of other individual variables and combinations were compared across the several groups. Frequency was the basis for identifying potential major causal factors.

A computer sorting routine was used to manipulate the data. For continuous variables, average values were computed.

A time series comparison was made separately by plotting monthly average water discharge rates against accident frequencies in the river segments.

Analysis findings were presented to towboat personnel and others actively working in the field. Their input was sought in interpreting and evaluating the validity of the findings. These practitioners were also invited to suggest ways of minimizing the likelihood of accidents.

Damage costs were examined by accident type. The cost data were taken from the reports. Data on claims settlements were obtained from marine insurers to assess the accuracy of the damage costs estimated during the accident investigation.

The analysis results are synthesized in "typical accident scenarios," the analysis end product called for in the statement of work for this study.

II. DATA SOURCES AND DATA BASE DEVELOPMENT

ACCIDENT-DESCRIPTIVE DATA

The U.S. Coast Guard's Report of Vessel Casualty or Accident, form CG-2692, the towing addendum, form CG-4724, and any narrative statements filed with those forms, are the basic documentation used in this study. The form 2692 must be submitted to the Coast Guard by the owner, agent, or master of each vessel damaged in an accident. The 4724 was also required during most of the study period, but it was discontinued in FY 1976 although it provided most valuable information for accident studies.

A special data collection instrument was prepared, identifying the data elements to be extracted from the reports and specifying a recording format suitable for computer input. The data elements are listed in Figure 2.1. The complete instrument ("Towboat Accident Questionnaire") is in Appendix B.

A separate from was used to record causal factors cited in the reports, along with case-identifying and descriptive information. (See Figure 2.2.) This chartlet information was organized by segment and used in conjunction with maps of the segments, copied from the Corps of Engineers charts of the waters, on which the accident locations were plotted. The accident segment charts and accompanying explanation forms, or "Chart Explanation Sheets," provided a means of relating segment features to the causal factors cited in the report.

1. Case Number

2. Official Number

3. Date of Casualty

4. Type of Casualty

   11 Overtaking collision of two or more separate, underway vessels
   12 Crossing " " " " " " " "
   13 Head on " " " " " " " "
   14 Other " " " " " " " "
   21 Bridge ramming
   22 Dike "
   23 Lock/Dam "
   24 Dock "
   25 Other "
   31 Ramming of another vessel anchored or moored
   41 Grounding
   51 Other

5. River Location of Casualty

   1. Lower Mississippi River head of passes to Milepoint 125
   2. Lower Mississippi River Milepoint 125 to Cairo, Illinois
   3. Upper Mississippi
   4. Ohio
   5. Illinois Waterway
   6. Gulf Intracoastal Waterway West

6. Milepoint Location of Casualty
   (To nearest tenth of mile)

7. Age of Operator

8. Birth Date of Operator

9. Years of Experience of Operator as Person in Charge

10. Number of Hours on Duty Prior to Casualty to Nearest Tenth of Hour

<u>Towboat Characteristics</u>

11. Gross Tonnage of Towboat

12. Length of Towboat

13. Horsepower of Towboat

FIGURE 2.1. DATA ELEMENTS SPECIFIED IN ACCIDENT QUESTIONNAIRE

14. Number of Propellers

15. Was Towboat Equiped with Flanking Rudders?

    Yes - 1

    No - 0

16. Was Equipment/Machinery Failure a Contributing Factor in Casualty?

    Yes - 1

    No - 0

17. Maximum Draft of Towboat
    (To nearest tenth of foot)

18. Year Built of Towboat
    (Last two digits only)

19. Case Number

20. Official Number

21. Direction of Movement of Tow Array

Upriver	-1
Downriver	-2
Not applicable	-3

22. Configuration of Tow Array

Pushing ahead	-1
Pulling astern	-2
Hip breast tow	-3
Other	-4

23. Number of Barges in Array

24. Number of Loaded Barges

25. Number of Light Barges

26. Total Cargo Tonnage

27. Overall Tow Array Length Including Towboat

28. Overall Tow Array Width Including Towboat

29. Maximum Draft of Any Barge in Array to Nearest Tenth of Foot

FIGURE 2.1. (Cont)

River Characteristics

30. Available Channel Width

    At lock, enter lock width (except on GIWW & Upper Miss. & Upper Ohio, single lock will be 0110; double will be 0220.)

31. Is there indication of high water or low water?

    High water - 01

    Low water - 02

32. From Chart, Fill in the Following Information Occurring Within 1/2 Mile on Either Side of The Casualty (If Cannot, Code 9) 8 indicates 8 or More

    Number of fixed span bridges
    " " movable " "
    " " locks/dams
    " " dikes
    " " bends
    " " bars and/or islands and/or rocks
    " " docks - 8 indicates 8 or more
    " " man-made structures
    " " canal or navigable rivers
    " " major port (must be 1 if #61 is 8)

33. Maximum Clear Span of Struck Bridge

    (000 if not applicable)

34. Time of Day of Casualty

    Day -1

    Night -2

    Twilight-3

35. Visibility at Time of Casualty

    Less than 1/4 mi -1

    1/4 to 1/2 -2

    1/2 to 1 -3

    1 to 2 -4

    Greater than 2 mi -5

36. Wind Speed at Time of Casualty

FIGURE 2.1. (Cont)

37. Weather at Time of Casualty

Clear -1
Partly cloudy -2
Overcast -3
Fog -4
Rain -5
Snow -6
Other -7

38. Wind Direction at Time of Accident

000

Upriver

270 090

Downriver

180

39. Was Radar On Board?

Yes - 1
No - 0
Yes, but not turned on - 2
Yes, but not operating properly - 3

40. Was Bridge to Bridge Radio Telephone Used?

No - 0
Yes - 1
Yes, but not properly - 2
Secondary vessel not involved - 3

FIGURE 2.1 (Cont)

Code	Case Number	Date	No. of Barges	Direction	Mile Point	Comments
R1	41201	05-07-73	1	Down	171	Rammed moored vessel. Strong winds and current rounding bend.
R2	41998	05-21-73	24	Down	170	Rammed moored vessel. Strong winds and current rounding bend
R3	41962	05-28-73	19	Down	171	Rammed moored vessel rounding bend in strong current.
C1	22092	01-30-72	3	Down	173	Mix-up in passing information. Head-on collision in bend.
C2	22285	11-16-71	45	Up	172.8	Mix-up in passing information. Head-on collision in bend.
C3	30197	04-15-72	3	Up	173	Failure to keep to right in sharp bend. Head-on collision.
C4	43141	02-06-74	2	Up	174	Tow backed out from pier into path

FIGURE 2.2 EXAMPLE OF ACCIDENT SEGMENT CHART EXPLANATION SHEET
MILE SEGMENT 170 (165-175) LOWER MISSISSIPPI RIVER

This procedure was necessary because reports rarely describe the location of the accident. The Chart Explanation Sheets are provided in Appendix C, separately bound. They may be useful in conjunction with the waterway charts for further analysis of local problems and solutions.

DAMAGE COSTS

Data on damage costs associated with towing vessel accidents were sought as a check on estimates during the accident investigations and reported on the forms 2692 and 4724. Damage cost may be used as an indicator of accident severity, and the accuracy of the estimates made before detailed damage assessment can be completed has been questioned.

Damage/loss costs are broken out in the Coast Guard reporting system for the vessel, cargo, and other property. In accidents of towboats with barges, damage to the towboat and to each barge is reported separately.

An in-depth comparison of estimated versus actual costs was not within the scope of this study. However, a limited inquiry was made into towboat damage only.[5] Sixty cases within the study sample were identified as having total damage of $30,000 or more, including damage to the towing vessel. Identifying data were taken from those 60 case reports and sent to five organizations which indicated willingness to provide information concerning the amount of claims paid. The five companies collectively represent a significant portion of the towboat underwriting industry, which is in itself a diverse group:

- American Marine Underwriters, Inc.
- Neare Gibbs and Company
- United States Salvage Association
- The Travelers Insurance Company
- Marine Office of America

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[5] Barges are normally insured by the towing companies and cargo by the shippers, requiring a multiplicity of contacts. Thus the inquiry was limited to the towboats themselves, insured by the marine underwriting industry.

TRAFFIC DENSITY

Traffic data were also sought to provide a baseline measure of opportunity, or exposure. The Department of the Army Corps of Engineers compiles data on commerce on the waterways in various manners, three of which were investigated in detail as possible sources from which to derive a measure of traffic for use in this study. The three sources include:

- "Waterborne Commerce of the United States - Part 2, Waterways and Harbors, Gulf Coast, Mississippi River, and Antilles," Calendar years 1972-1976
- Performance Monitoring System (PMS)
- Inland Navigation Simulation Model (INS).

Waterborne Commerce. This study provides yearly data compiled from industry sources on commodity flows and vessel transits on the U.S. waterways. The information provided includes number of towboat transits, number of barge transits, and gross tonnage, among other elements.

Performance Monitoring System (PMS). Beginning in 1976, the Corps instituted the PMS program, which requires the various locks in the waterway system to report all traffic utilizing those locks in detail - vessel name, number of barges, time of utilization, type of utilization, etc. The PMS, however, is not fully operational and does not encompass the entire system at this time.

Inland Navigation Simulation (INS) Model. This study is a first-order attempt by the Corps to simulate through a computer model the characteristics of the inland waterways, including lock and dam utilization, depths and currents, and commodity flow and activity of the two arrays transiting the waterways. The INS model, presently being updated, utilizes a 1975 data base compiled from Corps District Offices and provides data on the river system by "port equivalent."[2] The port equivalents are segments of the inland waterway

[2] See INSA "Port Equivalent" Definition and Listing, prepared by the Systems Analysis Applications Branch, Planning Division, Office of the Chief of Engineers, Department of the Army, Washington, D.C., April 1976.

system having relatively homogeneous river navigation characteristics, such that the complete set of segments spans the entire system. Figure 2.3 illustrates. The data reported by port equivalent include number of tow and barge transits for a "typical" 30-day period.

The INS data were selected for use in this study because they provide consistently derived measures for all of the specific accident locations that were included in the study. Waterborne Commerce would have provided aggregates for entire bodies of water, built from data on both commodity flows and port calls, whereas the PMS data would have provided precise counts of transits, but not for all locations of interest.

Charts were prepared relating traffic density to accident frequency as described in the Section I discussion of sample development. The complete set of charts is provided in Appendix A.

RIVER DISCHARGE DATA

Monthly river discharge data were obtained from the National Oceanographic and Atmospheric Administration. These data were plotted against accidents per month in each location and over all locations. The resulting charts permitted an assessment of the association between water flow rates and accident occurrence. In particular, they were an aid in clarifying the meaning of current effects as an accident causal factor.

EXPERT OPINION ABOUT NAVIGATIONAL PROBLEMS

Telephone and personal interviews were conducted with knowledgeable people in the towing industry, including pilots, captains, and company executives. A list of the organizations that assisted the study in this way is provided in the Acknowledgements at the front of this report. The interviews were conducted near the end of the study. The Chart Explanation Sheets (Figure 2.1) were provided for one or more areas, according to the interviewers' operating experience. Interviewees were asked to consult the pertinent charts. Other findings were presented verbally. The interviewees were invited to give their opinions as to the validity of study findings, to describe local problems in greater detail, and to suggest ways of increasing the reliability of vessel control.

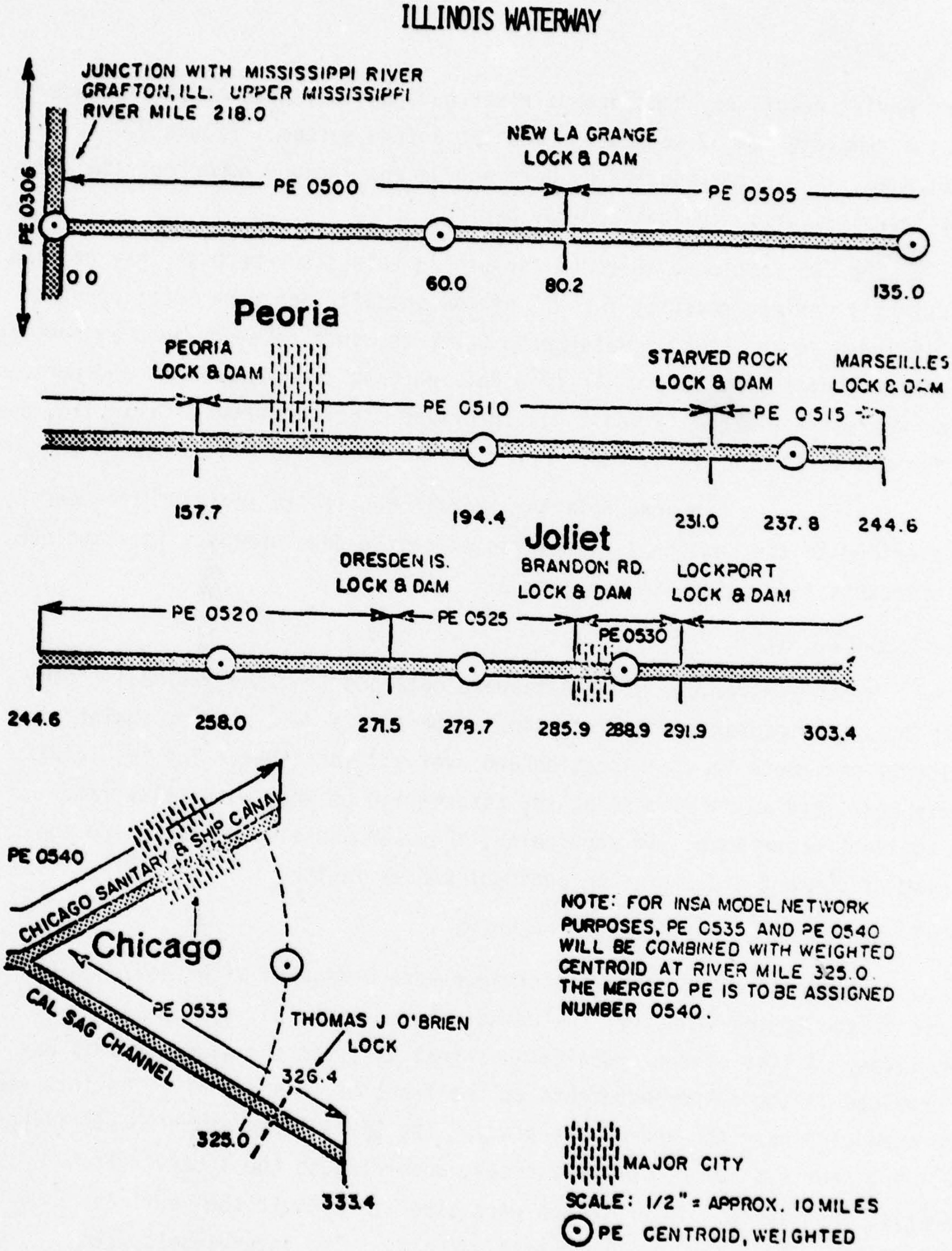

FIGURE 2.3. EXAMPLE OF AN INS PORT EQUIVALENT
(From INSA "Port Equivalent" Definition and Listing, prepared by the Systems Analysis Applications Branch, Planning Division, Office of the Chief of Engineers, Department of the Army, Washington, D.C., April 1976.)

The interviews were open-ended. No form was used. Experience in previous studies showed that it is more productive to stimulate conversation than to limit the information potential by a predefined set of questions. Notes were taken and a transcript of the notes is provided in Appendix D.

III. TRENDS IN ACCIDENT CHARACTERISTICS

This section presents the findings from the analysis of the accident reports and supplemental data. The topics addressed include:

1. Review of findings from the early examination of the geographic distribution of accidents and the distributions of accidents in relation to traffic. These are the findings on which the sample design was based, as discussed in Section I.
2. Accident types
3. Characteristics of the accident environments
4. Characteristics of the vessels involved in the accidents
5. Characteristics of the vessel personnel
6. Causal factors cited in the accident reports
7. Relationship between cited causal factors and the human performance requirements set forth in the Vessel Control Task Analysis done previously for the Coast Guard
8. Accident consequences as indicated by damage costs.

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The findings presented in the above topic areas were evaluated, interpreted and synthesized by the study team members, by practitioners in the towing industry, and by the Coast Guard personnel who monitored this study and reviewed the draft final report. The conclusions and recommendations drawn from this interpretive phase of the analysis are presented separately, in Section IV.

GEOGRAPHIC DISTRIBUTION OF ACCIDENTS

There are 27 major bodies of water in the system of navigable inland waterways of the United States. This study was defined to address the Gulf Intracoastal Waterway and the Western Rivers, including:

1. Upper and Lower Mississippi River
2. McClellan-Kerr Arkansas River Navigation System
3. Missouri River
4. Illinois Waterway
5. Monongahela River
6. Ohio River
7. Allegheny River
8. Kentucky River
9. Kanawha River
10. Green and Barren River
11. Tennessee River
12. Cumberland River
13. Black Warrior, Warrior and Tombigee River System

A total of 2,063 collisions, rammings, and groundings involving a towboat-barge configuration was reported to have occurred on these waters during FY 1972 through FY 1976 (the study population of accident cases). Eighty-six percent of those accidents occurred on four of the bodies of water--the Mississippi River, the Illinois Waterway, the Ohio River, and the Gulf Intracoastal Waterway (GIWW) West. (See Table 1.1 in Section I). On each of the other bodies of water, fewer than 20 accidents were reported during the 5-year study period, except for the GIWW East, with 114 accidents (6% of the total) and the Tennessee River with 85 (4% of the total). These data suggest the possibility of special navigational difficulties in parts of the system, which might stem from traffic relative to other parts and differences in physical characteristics, as well as distances traversed.

A closer look was taken at the distributions of accidents over all of the waterways, by determining the numbers of cases in 10-mile segments each year in the study period. Accidents on the nine waterways with relatively low accident frequency were found to be dispersed in both location and time. On the four "high frequency" waterways, clusters of accidents were observed in a field of dispersed accidents. Thirty-five 10-mile segments were identified wherein 10 or more accidents occurred during the study period -- 350 miles out of a total on the order of 3,000 miles. These findings suggest areas of unusual navigational difficulty. (See Tables 1.2 through 1.6 in Section I for more detailed data.)

Traffic data were sought to investigate the extent to which differences in traffic density over the waterway system might account for the accident cluster areas. Ratios of accidents to barges shipped were computed for each segment over each entire body of water. Controlling for traffic in this way, the segments previously identified continued to stand out as areas of high accident frequency. Additional areas were identified where fewer than 10 accidents were reported during the study period, but the frequency was high in relation to the amount of traffic. (See Section I for discussion of the "Traffic Factor" and Appendix A for further documentation.) Thus, it was decided to focus on those areas in the analysis. If common characteristics should be evident, they might represent major factors warranting first attention in any program to minimize the likelihood of collisions, rammings, and groundings.

Together, the accidents in the 35 high frequency segments comprise a 30% sample of the 2,063 cases initially identified. It is stressed, however, that the sample is purposeful, not random. Rather than attempting to represent the total population of 2,063 accidents, it was decided to reduce the population in effect, by concentrating where there appeared to be the greatest potential for returns in the form of safety improvements. The sample findings should be generalized only, if at all, to other segments of the waterway system wherein environmental factors and other characteristics of the towboat operations, as described in later in this section, are similar.

Accident Types

Ramming was found to be the predominant accident type. Over half (53%) of the total population of 2,063 accidents were rammings. In the segment sample, rammings comprise 64% of the total.

Collisions and groundings are found about equally in the total population -- just under 25% each. A comparable proportion (26%) of collisions is found in the segment sample. Groundings are somewhat underrepresented in the segment sample (19%) compared to their incidence in the total study population of cases. Table 3.1 summarizes these findings.

Although the sample is not a statistical sample of the population, it represents reasonably well the relative prominence of the three major classifications of vessel control accidents.

NUMBER OF CASES

The analysis of the geographic distribution of accidents during the study period was done using listings from the Coast Guard's Automated Vessel Casualty File. It yielded a total sample of 614. When the reports were studied for the purpose of data extraction, 25 cases were found which did not fit the population definition or were outside the location sample (e.g., the case was actually a structural failure, a breakaway barge struck a fixed object, there was an error in the location code, etc.) Thus the analysis actually worked with a total of 589 cases.

PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS

This subsection addresses physical features of the waterway and transient environmental conditions. The variables considered are structures, bends, current direction relative to tow direction, time of day, and visibility.

Structures and Bends

Four categories of physical features were found to predominate in the high-accident-frequency segments of the study sample: one or more bridges, one or more locks, one or more of both, and bends (often near a bridge or lock). Tables 3.1 and 3.2 give the incidence of accidents in relation to those features. The following is shown:

- For all waterways except the GIWW, roughly 60% to 85% of the accidents took place where there was one or more bridges, locks, or both (Table 3.1).
- On the GIWW just about half of the accidents took place where there was one or more bridges, locks, or both (Table 3.1).
- In 246 (65%) of the 380 accidents at bridges, locks, or a combination, there was also a bend within ½ mile of the structure (Table 3.2).
- Of the accidents that did not occur at a bridge or lock, 144 (76%) occurred at a bend (Table 3.2).

TABLE 3.1

INCIDENCE OF ACCIDENTS IN RELATION TO
MAJOR STRUCTURES, BY WATERWAY

Physical Features	Lower Miss.	Upper Miss.	Ohio	Illinois	GIWW	Total
Bridge(s) only	31 (63%)	42 (42%)	20 (17%)	57 (66%)	85 (40%)	235 (41%)
Lock(s) only	0	14 (14%)	74 (62%)	6 (7%)	17 (8%)	111 (20%)
Complex (bridge and lock)	0	14 (14%)	8 (7%)	8 (9%)	4 (2%)	34 (6%)
Total	31 (63%)	70 (70%)	102 (86%)	71 (82%)	106 (49%)	380 (67%)
All other locations	18 (37%)	29 (29%)	17 (14%)	16 (18%)	109 (51%)	189 (33%)
Grand Total	49 (100%)	99 (100%)	119 (100%)	87 (100%)	215 (100%)	569 (100%)

TABLE 3.2

INCIDENCE OF ACCIDENTS AT BENDS

Bend within ½ Mile	Lower Miss.	Upper Miss.	Ohio	Illinois	GIWW*	Total
(a) Accidents at Bridges/Locks or in Complex Locations**						
Yes	31	25 (36%)	50 (49%)	56 (79%)	84 (79%)	246 (65%)
No	0	45 (64%)	52 (51%)	15 (21%)	22 (21%)	134 (45%)
Total	31 (100%)	70 (100%)	102 (100%)	71 (100%)	106 (100%)	380 (100%)
(b) All other Accidents						
Yes	17 (94%)	21 (72%)	8 (47%)	14 (88%)	84 (77%)	144 (76%)
No	1 (6%)	8 (28%)	9 (53%)	2 (12%)	25 (23%)	45 (24%)
Total	18 (100%)	29 (100%)	17 (100%)	16 (100%)	109 (100%)	189 (100%)
(c) All Accidents ("a" and "b" combined)						
Yes	48 (98%)	46 (46%)	58 (49%)	70 (80%)	168 (78%)	390 (69%)
No	1 (2%)	53 (54%)	61 (51%)	17 (20%)	47 (22%)	179 (31%)
Total	49 (100%)	99 (100%)	119 (100%)	87 (100%)	215 (100%)	569 (100%)

* Intersections are counted as bends on the GIWW.

** "Complex" refers to locations in which there is a bridge and a lock in close proximity.

Bridge piers reduce the available channel width. Depending on the width of the tow, it may be difficult or impossible to pass another vessel while negotiating a bridge (including the approach and exit). Moreover, there may be only a few feet of clearance for a single tow, so that proper alignment to pass safely between the bridge piers is critical.

If a heading adjustment should be required to avoid some hazard (say a shoaling area, a grounded/moored vessel), if current or some other force should alter a vessel's position or orientation, if the inherent maneuverability of the tow is less than optimal and timing is off, the vessel may reach the bridge out of alignment for clearance or it may get into some other kind of difficulty because of the limitations imposed by the structure.

Locks are even more restrictive and involve a somewhat different set of problems. A lock is approached and exited at very slow speed. Tows may have to queue up to pass through, resulting in some congestion on either side. Tows are often intentionally grounded to wait their turn, and there may be difficulty in starting up and getting aligned within a relatively short distance from the gate. Cross currents are created below locks, which may have strong impacts at slow speed.

Interviews with pilots have identified bends as problems for tows operating downriver, especially where a bridge is located close after the bend (within a mile or less, depending on the size of the tow). As the tow steers around a bend, inertial forces cause it to slide in a direction opposite to the direction of the turn, like a car on ice. In addition, current flow in a bend tends to push the tow in the direction it is sliding. Thus a tow holding the left descending bank and approaching a left turn bend can be swept across the river toward the right descending bank as it negotiates the bend. It apparently does not take exceptionally strong currents to make this happen.

Mix of Accident Types in Relation to Major Structures

As shown in Table 3.3, 77% of all accidents at bridges, locks, or in complex locations were rammings of fixed objects - namely, the bridges and locks. The table also shows that the GIWW dominates in the accidents at locations where there was no bridge or lock. Roughly half of such accidents

TABLE 3.3

COMPARISON OF MIX OF ACCIDENT TYPES IN LOCATIONS
WITH AND WITHOUT MAJOR STRUCTURES

Accident Type	Lower Miss.	Upper Miss.	Ohio	Illinois	GIWW	Total
Accidents at Bridges, Locks, or Complex Locations						
Collision with moving vessel	0	1 (1%)	1 (<1%)	4 (6%)	14 (13%)	20 (5%)
Ramming						
- Fixed object	26 (84%)	60 (86%)	88 (86%)	55 (77%)	65 (61%)	294 (77%)
- Moored vessel	4 (13%)	4 (6%)	1 (<1%)	8 (11%)	8 (8%)	25 (7%)
Grounding	1 (3%)	4 (6%)	12 (12%)	4 (6%)	19 (18%)	40 (1%)
Other	0	1 (1%)	0	0	0	1 (<1%)
Total	31 (100%)	70 (100%)	102 (100%)	71 (100%)	106 (100%)	380 (100%)
Accidents in Other Locations						
Collision with moving vessel	10	2	5	2	51 (47%)	70 (37%)
Ramming:						
- Fixed object	0	3	6	3	13 (12%)	25 (13%)
- Moored vessel	7	5	0	6	23 (21%)	41 (22%)
Grounding	1	18	6	4	22 (20%)	51 (27%)
Other	0	1	0	1	0	2 (1%)
Total	18	29	17	16	109 (100%)	189 (100%)

on the GIWW were collisions with other moving vessels. Groundings and rammings of moored vessels (which includes grounded tows) were the next most frequent accident types.

Because of the dominance of the single accident type in the bridge/lock cases, accident type is not broken out in subsequent analysis of those cases. Similarly, because of the small numbers of non-bridge/lock accidents on three of the five waterways, those accidents are not broken out by waterway in subsequent tabulations. The non-bridge/lock accidents are broken out by type.

Current Direction Relative to Tow

An upriver transit is against the current and a downriver transit is with the current. In a critical situation, it is much easier to stop or slow the tow when proceeding upriver. In some sections of the rivers, a towboat proceeding down during high water may not have sufficient horsepower to stop the tow in a timely fashion.

It was found that 56% to 88% of the accidents on the rivers in this study occurred during downriver passages. Table 3.4 provides a comparison for accidents at bridges, locks, and complex locations (bridge and lock).

The table shows that there may be differences in current effects when negotiating locks. Except on the Upper Mississippi, there is an even split between lock accidents of tows heading upriver and those heading down. It should be noted that with only 13 accidents at locks on the Upper Mississippi, the percentage difference may be misleading.

Even though a tow is proceeding upriver, current may still cause significant control difficulty at a lock, especially in view of the speed factor. A large eddy occurs just below the dam, which creates cross currents for upbound tows entering the lock from below. A lock is approached at slow speed, making it difficult to counter the current force.

TABLE 3.4

INCIDENCE OF ACCIDENTS RELATED TO DIRECTION OF PASSAGE AND PHYSICAL FEATURES, BY RIVER *

Direction of Passage	Lower Miss.	Upper Miss.	Ohio	Illinois	Total
			Accidents at Bridges		
Upriver	3 (12%)	6 (14%)	2 (11%)	19 (34%)	30 (21%)
Downriver	23 (88%)	36 (86%)	17 (89%)	37 (66%)	113 (79%)
Total	26	42	19	56	143
			Accidents at Locks		
Upriver	-	3 (23%)	40 (55%)	3 (50%)	46 (50%)
Downriver	-	10 (77%)	33 (45%)	3 (50%)	46 (50%)
Total		13	73	6	92
			Accidents in Complex Locations		
Upriver	-	4 (36%)	2 (25%)	0	6 (22%)
Downriver	-	7 (64%)	6 (75%)	8	21 (78%)
Total		11	8	8	27

* This table includes a total of 262 cases. This is mostly because of the exclusion of the GIWW (106 cases), where direction of current is not applicable. In 12 cases it was not possible to determine the direction of passage from the information given in the report.

Table 3.5 gives the direction of passage for all other accidents for which the information was reported. This table also suggests that downriver passage is more hazardous, especially increasing the likelihood of a grounding and (although the number of cases is small) a collision with a moored vessel. These results are reasonable considering differences in current effects down and up and also considering the presence of bends in most of these cases and the slide effect previously described. Accidents on the GIWW are excluded because there is no current direction.

TABLE 3.5

UPRIVER VERSUS DOWNRIVER ACCIDENTS WHERE BRIDGES AND LOCKS WERE NOT PART OF THE ACCIDENT SCENARIO BY TYPE OF ACCIDENT

(Excludes accidents on the GIWW.)

Direction of Passage	Hit Moving Vessel	Hit Fixed Object	Hit Moored Vessel	Groundings, Other	Total
Upriver	11 (61%)	6 (60%)	6 (33%)	7 (25%)	30 (38%)
Downriver	7 (39%)	4 (40%)	12 (67%)	21 (75%)	48 (62%)
Total	18 (100%)	10 (100%)	18 (100%)	28 (100%)	78 (100%)

With regard to collisions with another moving vessel, in most of these cases the vessels were meeting and, as is evident, one was proceeding downriver. The numbers in Table 3.5 are for the "primary vessel" only. The primary vessel was specified to be a towboat with barges, but otherwise was arbitrarily designated. The "other" vessel could also be a towboat with barges subject to the special downriver control difficulties that have been discussed.

River Stage

Since downbound tows predominate among the river accident cases, indicating current as a major factor, more accidents might be expected to occur during periods of peak water, when the current is particularly forceful. The groundings might be different, i.e., they might be expected to occur more often when the water is low. To explore these possibilities, a time series was made relating numbers of collisions, rammings, and groundings to river discharge rate.

Discharge data are obtained at specific river locations where there are gauging stations which document the daily flow. These data do not exactly represent the flow situation hundreds of miles above and below the station, but when averaged on a monthly basis they are sufficient for the study purpose. Discharge rates measured in cubic feet per second, were plotted by month, and bars representing the number of accidents of each type were superimposed on the discharge curves. The comparison was made for a portion of each river in the study.

In general, some tendency was observed for accidents to occur more often during the higher river stages. However, a sizable number of accidents took place at the beginning of a peak, when the water level was rising, and at the end of a peak, when the water was falling. Some accidents occur at the peaks, but not as many as expected. It appears most probable that, in the kinds of areas represented by the study sample, the maneuvering limitations are such that moderate forces, as during medium discharge periods, are sufficient to create difficulties in vessel control. In addition, there may be some curtailment of operations during peak periods.

The groundings are not shown to be concentrated in low water periods. A large percentage of the groundings in this study occurred at bends and factors other than low water appear to have been involved.

Overall, it appears that accidents at bridges do tend to occur more often during high water, whereas accidents at locks/dams and in complex locations where both lock/dam and bridge are present, occur throughout the range of river stage, with no clear trend evident.

A summary of the findings follows, for each section of water for which the analysis was done (a portion of each river). The complete results are presented in Figures 3.1 through 3.9, following the summary.

<u>Lower Mississippi River, Mile 330 to 600 (Figure 3.1)</u>

Accidents (collisions, groundings, or rammings) all occurred within peaks of the water discharge series, which suggests an association between river stage and the occurrence of accidents. Accidents primarily occurred in the vicinity of bridges at Vicksburg and Greenville.

<u>Upper Mississippi River, Mile 000 to 220 (Figure 3.2)</u>

Accidents seem to occur with more frequency during low water stages although a number of them do occur during high water. Suggestion is that there is no direct relationship between river stage and the occurrence of accidents. Most accidents occurred at a bridge and/or lock/dam.

<u>Upper Mississippi River, Mile 220 to 453 (Figure 3.3)</u>

Here almost all accidents occurred during the higher river stages. Most accidents occurred in the vicinity of a bridge.

<u>Ohio River, Beginning to Mile 450 (Figure 3.4)</u>

The distribution of accidents appears to be independent of river stage: i.e., accidents are more or less evenly distributed through various river stages. Most accidents occurred in the vicinity of a lock/dam.

<u>Ohio River, Mile 550 to 780 (Figure 3.5)</u>

No real trend between river stage and accidents can be seen, although it may be that accidents occur more frequently within this river segment during low river stages. Most accidents occurred in the vicinity of a bridge and/or lock/dam.

<u>Ohio River, Mile 780 to 950 (Figure 3.6)</u>

Accidents appear to be evenly distributed through the full range of river stages. (Dashed lines indicate missing water discharge data which have been interpolated.) Again, most accidents occurred in the vicinity of a lock/dam.

Ohio River, Mile 950 to 980 (Figure 3.7)

The small number of accidents makes it difficult to draw any conclusions. However, almost all accidents occurred during the higher river stages. Most accidents were in the vicinity of a bridge and/or fleeting area.

Illinois Waterway, Mile 000 to 180 (Figure 3.8)

From 1972 to 1974, with one exception, accidents occurred during high water stages. In 1975 and 1976, however, accidents occurred throughout the range of river stages. Most accidents were in the vicinity of a narrow-span bridge.

Illinois Waterway, Mile 180 to 300 (Figure 3.9)

Accidents seem to be rather evenly distributed through water stages, although, with the exception of the unusually long low-water period in 1976, higher monthly accident totals occur with higher river stages. Again, most accidents were in the vicinity of a bridge.

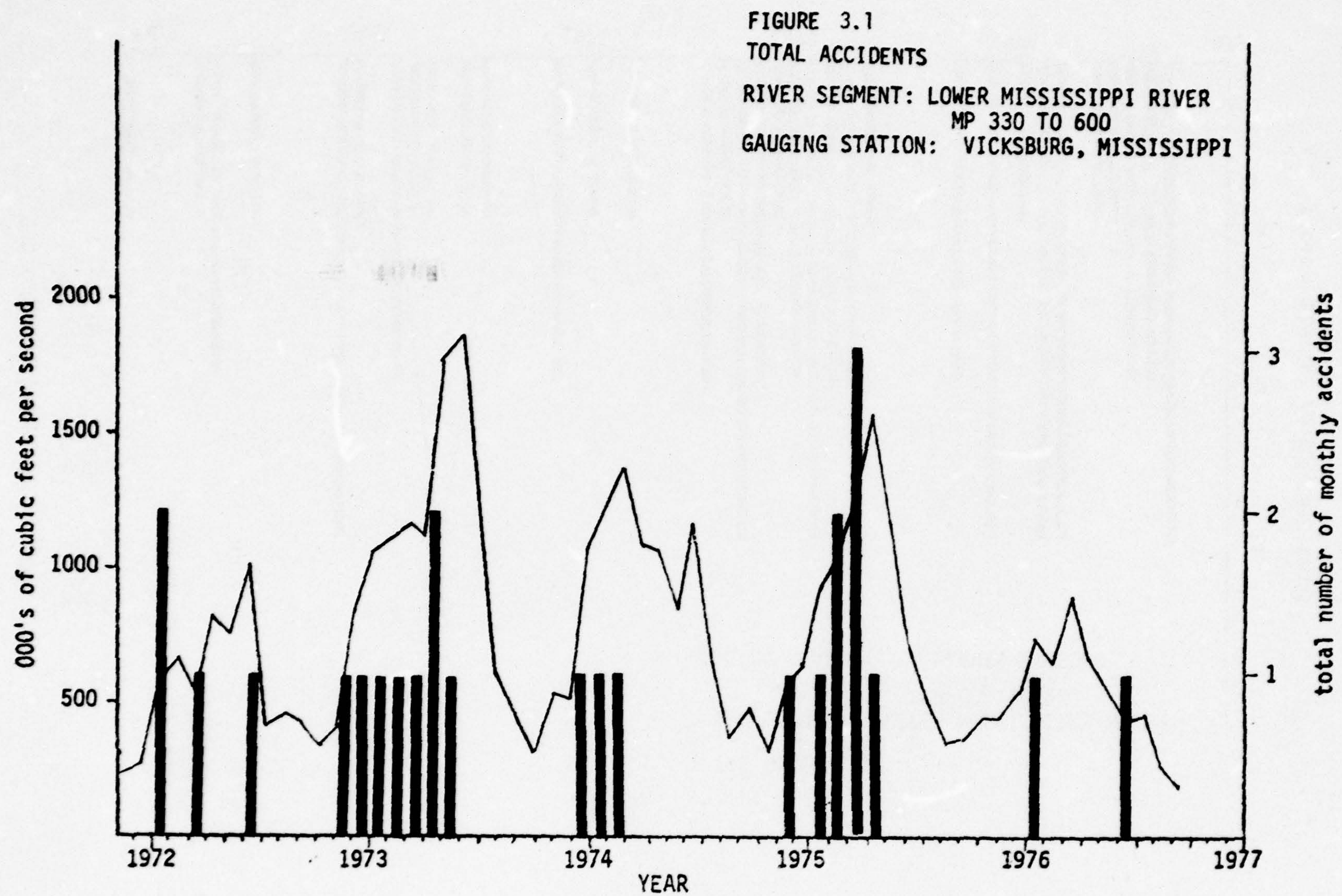
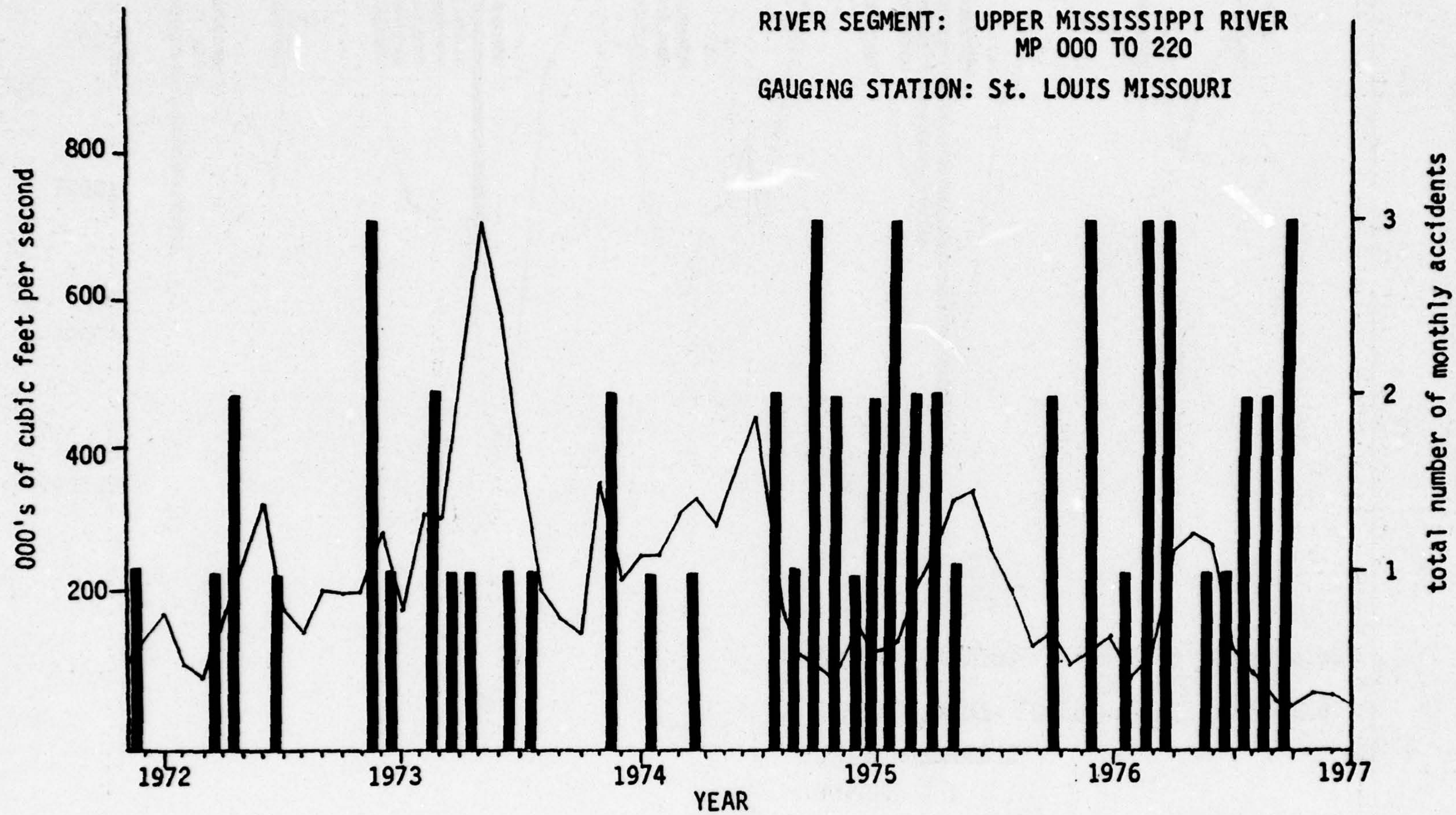


FIGURE 3.1
TOTAL ACCIDENTS
RIVER SEGMENT: LOWER MISSISSIPPI RIVER
MP 330 TO 600
GAUGING STATION: VICKSBURG, MISSISSIPPI

FIGURE 3.2
TOTAL ACCIDENTS

RIVER SEGMENT: UPPER MISSISSIPPI RIVER
MP 000 TO 220

GAUGING STATION: St. LOUIS MISSOURI



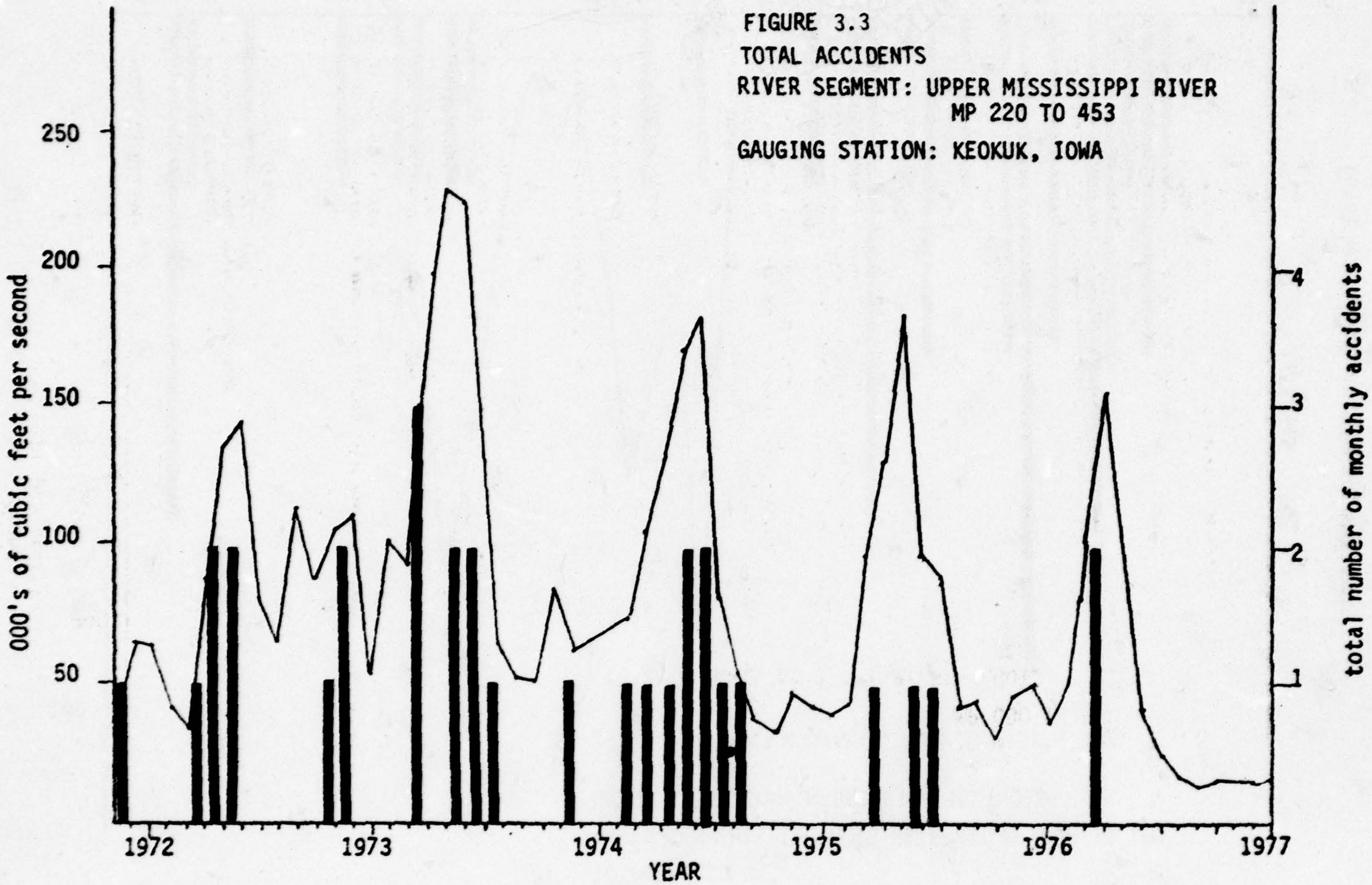
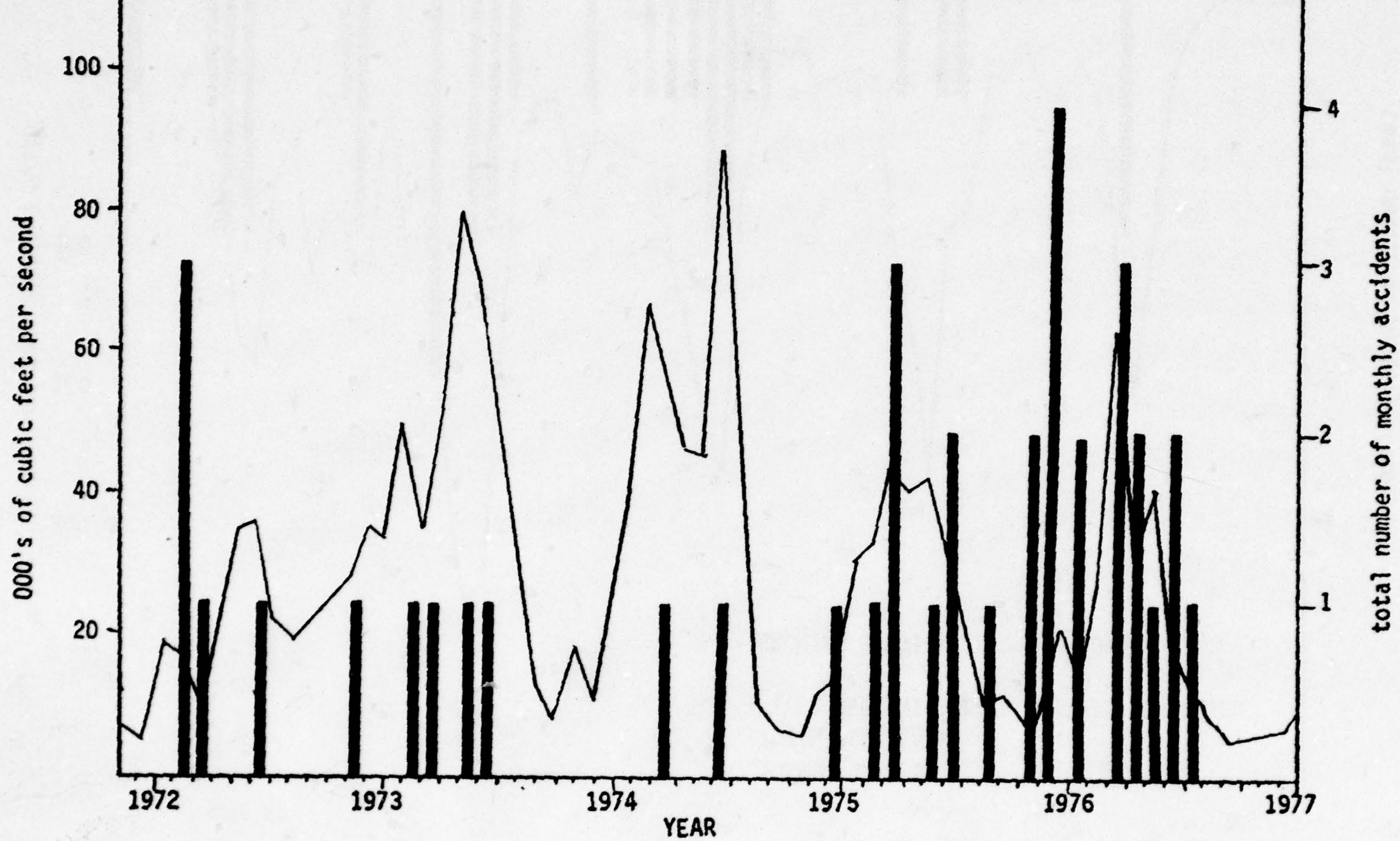


FIGURE 3.3
TOTAL ACCIDENTS
RIVER SEGMENT: UPPER MISSISSIPPI RIVER
MP 220 TO 453
GAUGING STATION: KEOKUK, IOWA

FIGURE 3.4
TOTAL ACCIDENTS
RIVER SEGMENT: ILLINOIS WATERWAY MP 000 TO 180
GAUGING STATION: MEREDOSIA, ILLINOIS



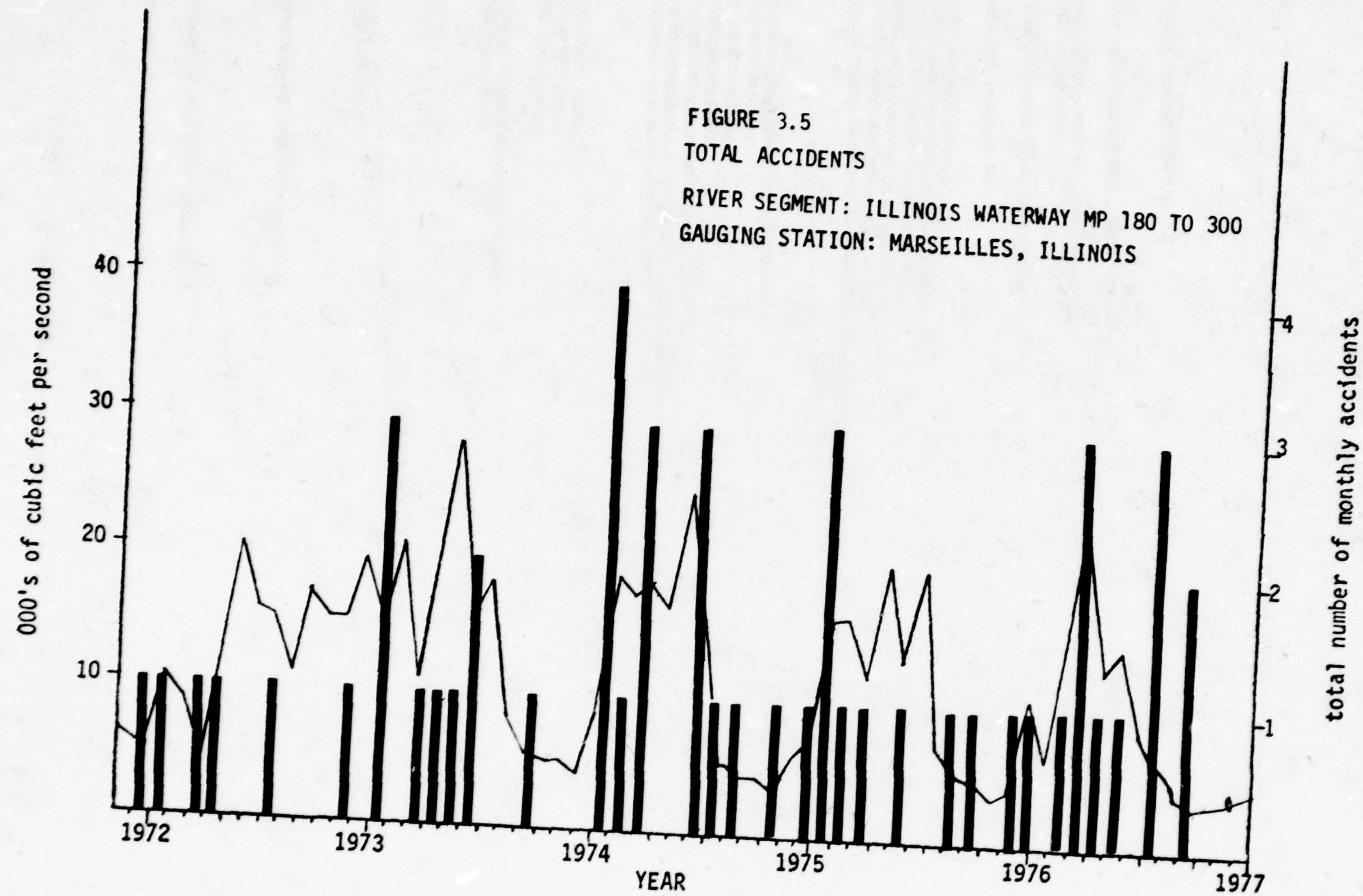


FIGURE 3.5
TOTAL ACCIDENTS
RIVER SEGMENT: ILLINOIS WATERWAY MP 180 TO 300
GAUGING STATION: MARSEILLES, ILLINOIS

FIGURE 3.6
TOTAL ACCIDENTS
RIVER SEGMENT: OHIO RIVER
BEGINNING TO MP 350
GAUGING STATION: GREENUP DAM
GREENUP, KENTUCKY

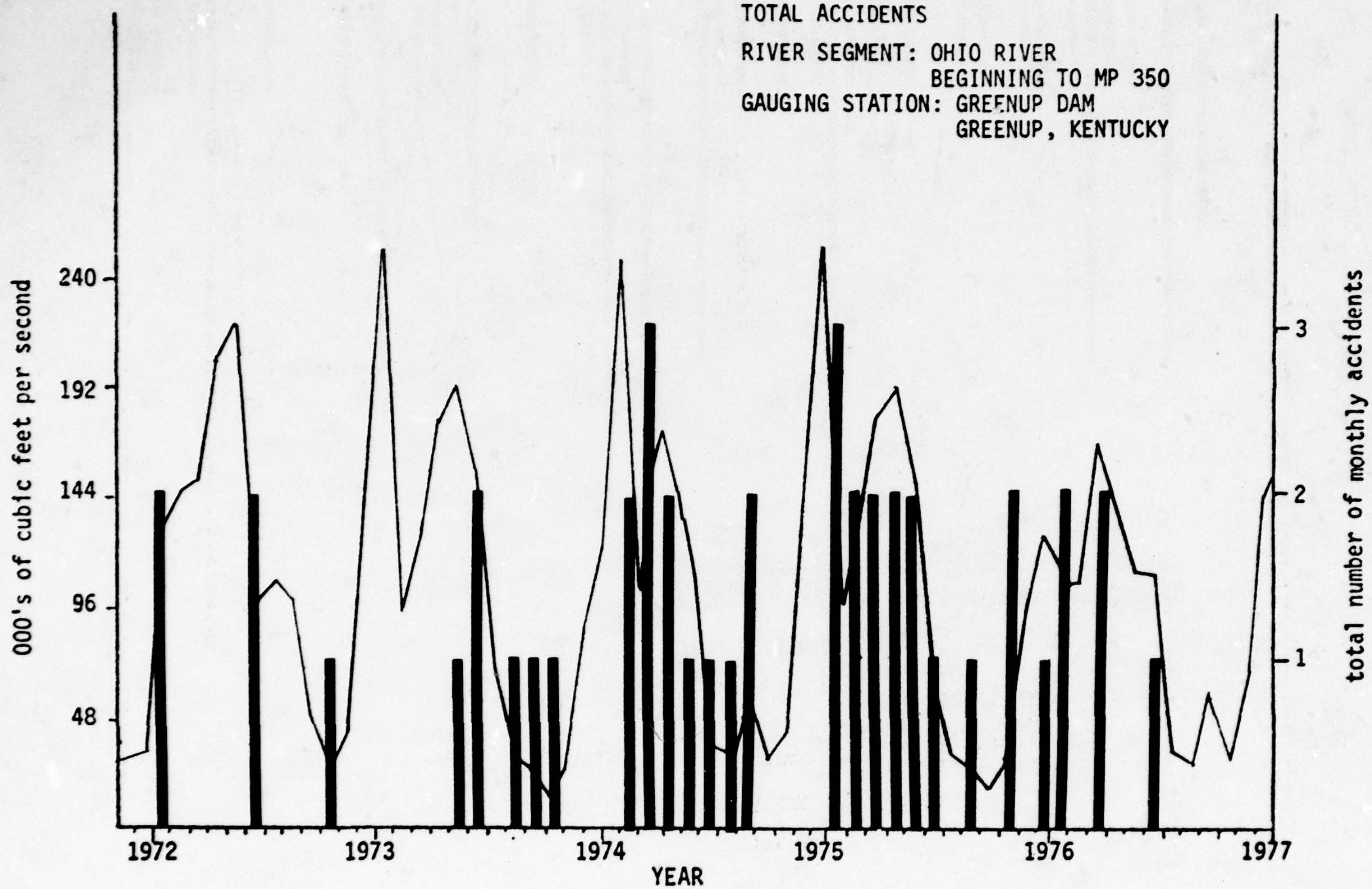


FIGURE 3.7

TOTAL ACCIDENTS

RIVER SEGMENT: OHIO RIVER
MP 550 TO 780

GAUGING STATION: LOUISVILLE, KENTUCKY

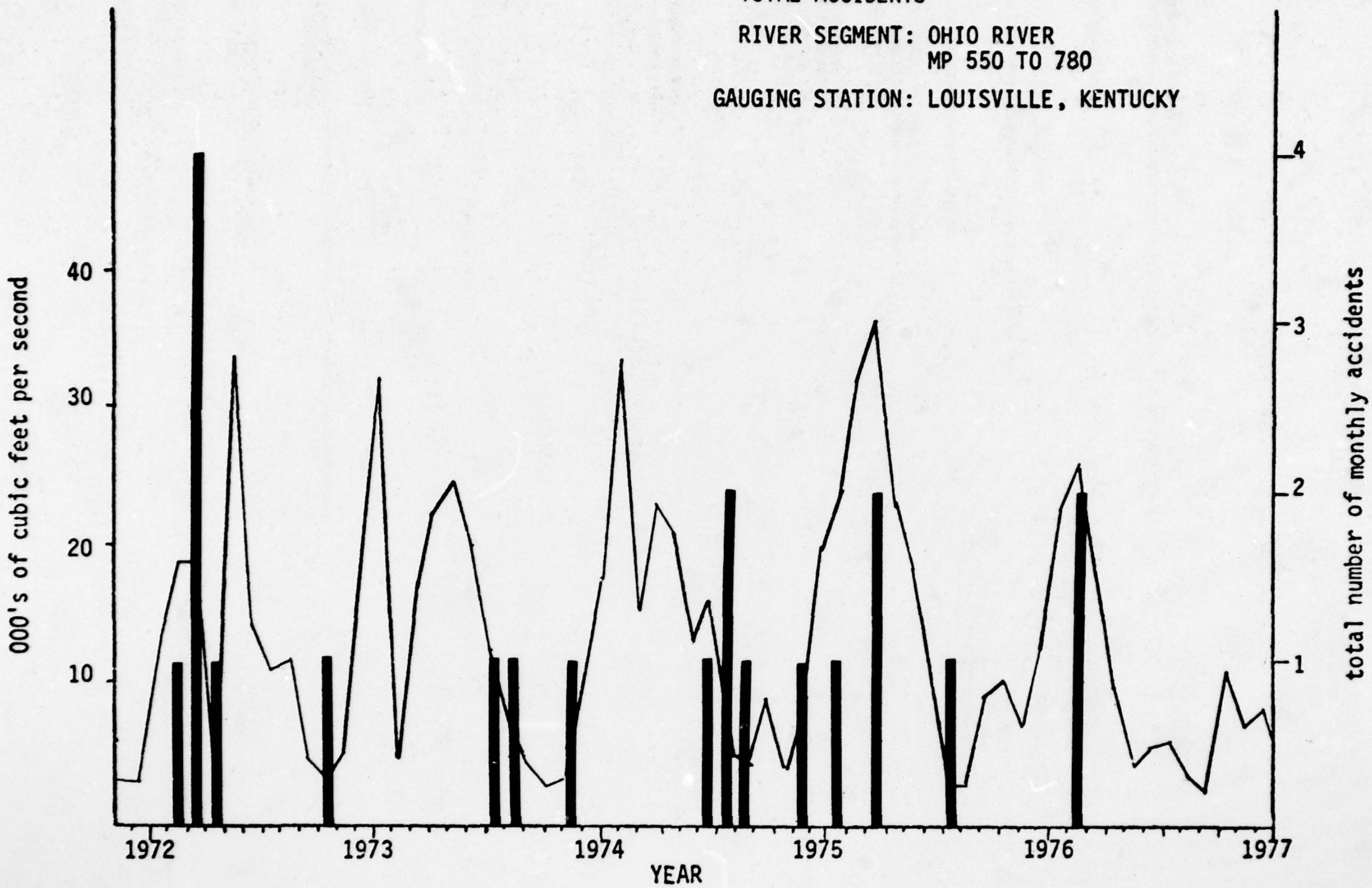


FIGURE 3.8

TOTAL ACCIDENTS

RIVER SEGMENT: OHIO RIVER
MP 780 TO 950

GAUGING STATION: EVANSVILLE, INDIANA

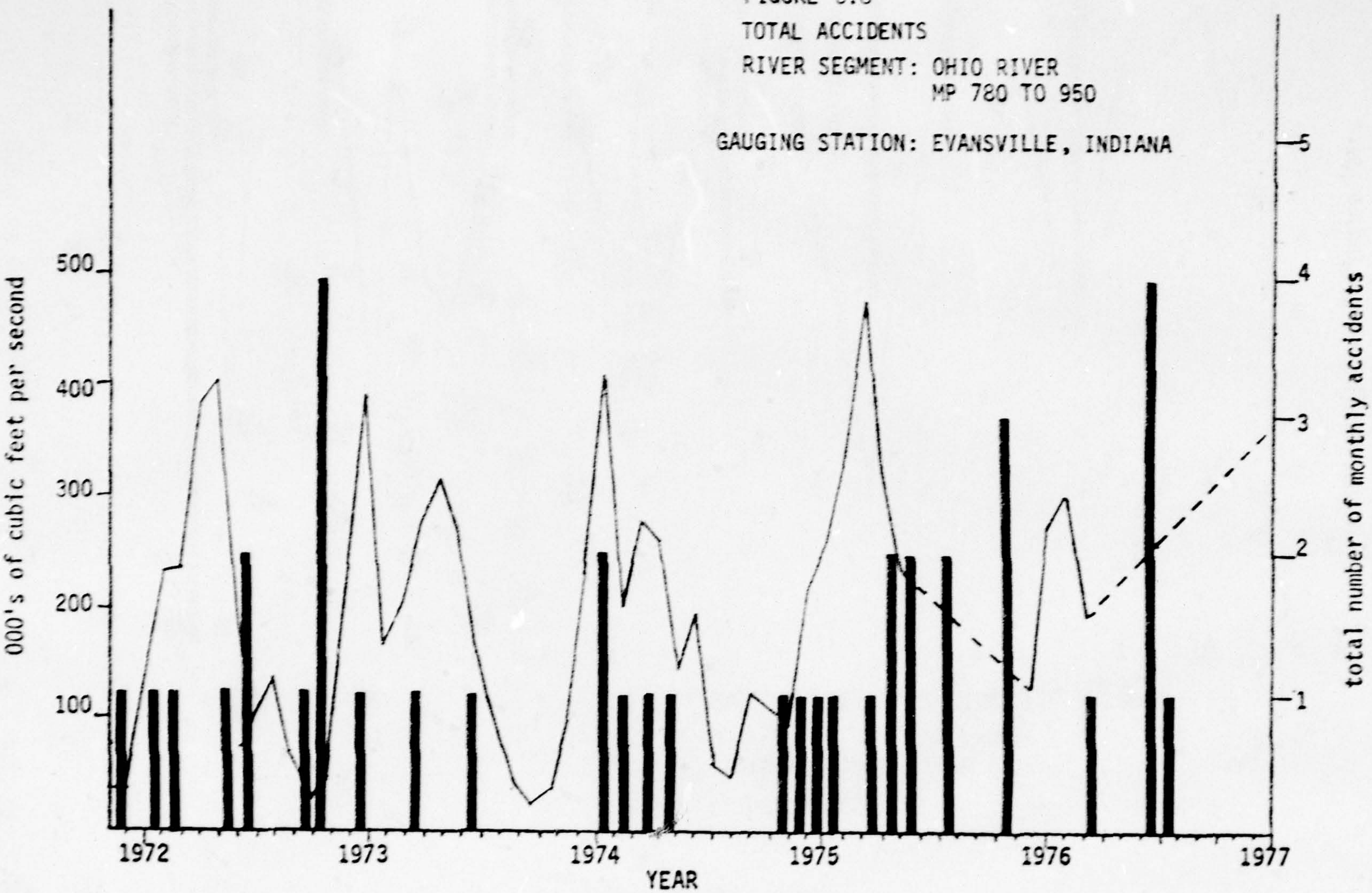
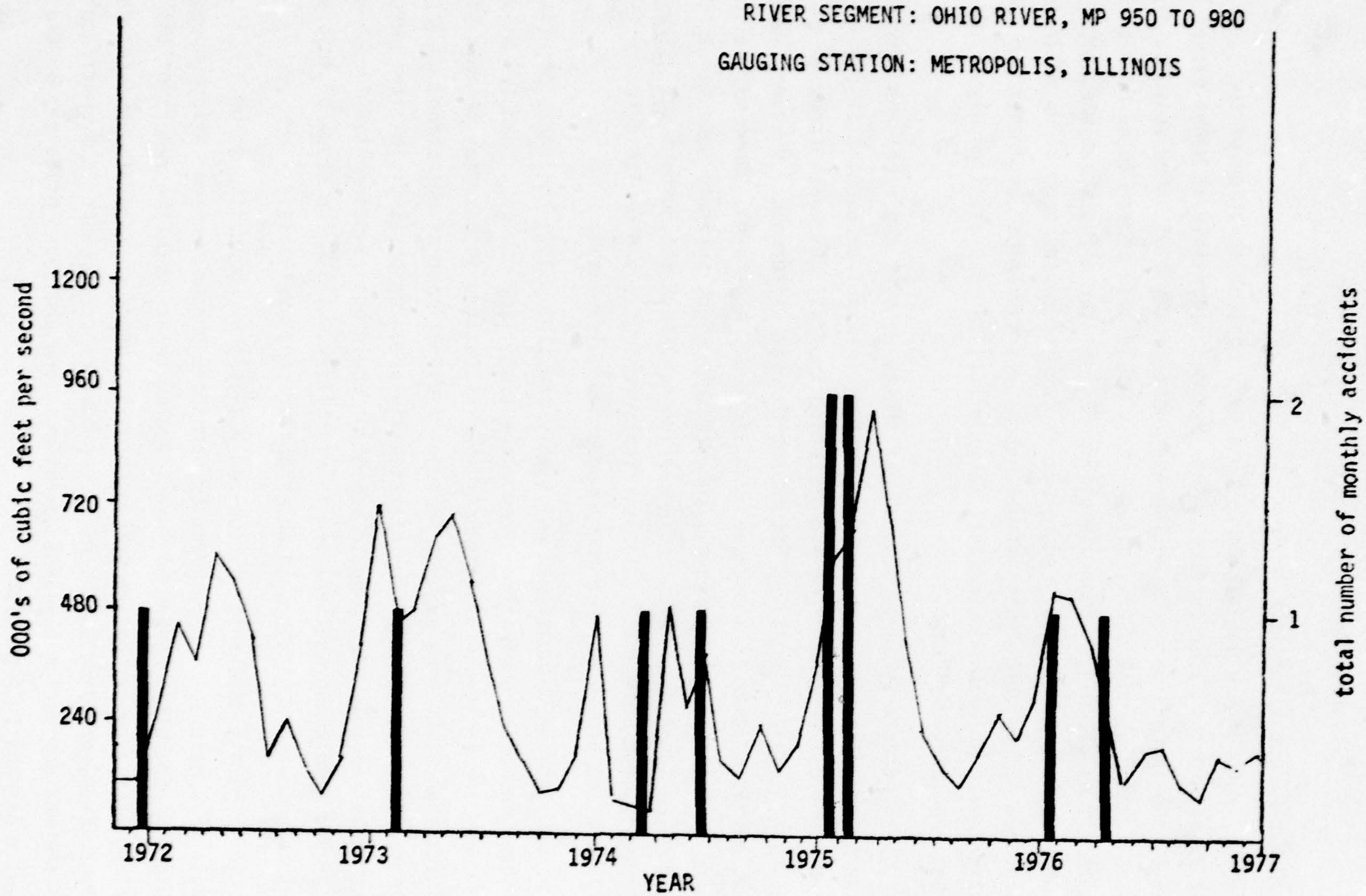


FIGURE 3.9

TOTAL ACCIDENTS

RIVER SEGMENT: OHIO RIVER, MP 950 TO 980

GAUGING STATION: METROPOLIS, ILLINOIS



Time of Day and Visibility

Much of tow navigation is done by visual observation of the banks of the river and the water surface. This becomes impossible at night except by use of the searchlight. Detection and identification of other vessels, aids to navigation, bridge piers, dikes, etc., would also appear to be made more difficult by darkness. Poor visibility has similar effects but more pronounced. Towboat pilots make use of radar, but it cannot provide some kinds of information that may be obtained by visual watch. It should be noted that our conversations with pilots indicate that they do not, in general, find nighttime operations more difficult.

The data in Table 3.6 suggest, however, that under certain circumstances darkness may be an accident factor. Fifty-four percent of the accidents at bridges occurred at night and 4% during the twilight hours (predawn and dusk), versus 42% during the day. This is not a great difference. However, assuming that operating time is about evenly divided day and night, there may be something of interest here. Roughly the same day-night split is seen for accidents in complex locations, which include bridges, though the numbers are quite small. Similarly, for accidents at locks, night problems could be indicated on the Illinois and GIWW-West, but the numbers are quite small.

Table 3.6 shows that relatively few (10% - 15%) accidents occurred at bridge, lock, or combination sites where visibility was less than 1/4 mile. However, the incidence of accidents when visibility is poor may be more significant than study data suggest because of curtailment of operations during such times. Tows are quite often intentionally grounded until visibility improves. The number of tows operating in a segment could not be documented for specific days and times, and thus related to visibility, within the scope of this study. Suitable source data for such an effort are not available.

Pilots have told us repeatedly that they would like to have reflective material and/or radar transponders put on vertical bridge supports (piers). The piers cannot be identified on radar since the return of the bridge itself masks the supports. Moreover, under certain atmospheric conditions (haze, drizzle, smoke, etc.) the bare concrete supports are difficult to see unaided during daylight operations, and are poor reflectors of the towboat's searchlights at night.

TABLE 3.6

TIME OF DAY AND VISIBILITY CONDITION WHEN ACCIDENTS OCCURRED, IN RELATION TO PHYSICAL FEATURES, BY RIVER*

Time of Day, Visibility	Lower Miss.	Upper Miss.	Ohio	Illinois	GIWW	Total
Accidents at Bridges						
Day	14 (45%)	17 (40%)	6 (30%)	22 (39%)	40 (47%)	99 (42%)
Night	16 (52%)	23 (55%)	14 (70%)	32 (56%)	41 (48%)	126 (54%)
Twilight	1 (3%)	2 (5%)	0	3 (5%)	4 (5%)	10 (4%)
Total	31	42	20	57	85	235
Night, twilight combined	17 (55%)	25 (60%)		35 (61%)	45 (53%)	136 (58%)
Visibility <1 mi.	5 (17%)	4 (10%)	4 (21%)	8 (15%)	3 (4%)	24 (11%)
Visibility >1 mi.	25 (83%)	35 (90%)	15 (79%)	45 (85%)	76 (96%)	196 (89%)
Total	30	39	19	53	79	220
Accidents at Locks						
Day		8	37	2	6	53 (48%)
Night		4	36	4	11	55 (50%)
Twilight		2	1	0	0	3 (3%)
Total		14	74	6	17	111
Night, twilight combined		6	37			58 (52%)
Visibility <1 mi.		0	13	1	2	16 (15%)
Visibility >1 mi.		13	61	5	11	90 (85%)
Accidents at Complex Locations (bridge and lock)						
Day		10	1	3	0	14 (42%)
Night		4	6	5	4	19 (58%)
Twilight		0	0	0	0	0
Total		14	7	8	4	33
Visibility <1 mi.		0	0	3	0	3 (10%)
Visibility >1 mi.		11	8	5	4	28 (90%)

* Table includes 379 cases for which time of day was stated in the accident report and 359 cases for which the visibility was stated. The total number of accidents at bridge, lock, and complex locations was 380.

Towboat and Array Characteristics

Towboat Age. Figure 3.10 showing accidents per towboat in age category, suggests that older towboats (built prior to 1945) had a significantly better accident record than those built thereafter. However, it is strongly suspected that towboats built prior to 1945 are used less often and for less difficult runs than the post-1945 towboats. Thus their lower accident rates would be accounted for at least partly by less exposure. Also, they are already exceptional survivors, being, for whatever reasons, less accident prone than contemporaries that are no longer operating.

The post-1945 boats probably have nearly equal exposure, and Figure 3.10 suggests that accidents among these boats are independent of their age; i.e., the accident rate (or at least the faired-in curve) is more or less constant. It is concluded that there is no significant relationship between accident occurrence and towboat age.

Towboat Horsepower. The earlier ORI study of bridge rammings suggested that underpowering might be a factor in such accidents, at least on the Mississippi River.[1] The findings of the present study concerning direction of transit, river stage, the frequency of accidents at bends and the frequency with which current was cited as a causal factor in the accident reports, all suggest that the power question should be examined. To do so, horsepower data were compared for the towboats involved in the accident sample and the total population of towboats in existence as of 1 January 1976.[2] It is noted that horsepower should be considered in relation to measures of the load as well as the forces and other maneuvering constraints encountered by the vessel. Although in-depth analysis of tow controllability and towboat power requirements was not accomplished within the scope of the study, the load parameter and other related parameters are discussed in the next subsections.

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[1] R.B. Dayton, Analysis of Bridge Collision Incidents, Silver Spring Maryland: ORI, Inc., May 1976 (Volume I) and December 1976 (Volume II). NTIS AD A029034 and AD A036732.

[2] The data source used for this purpose was Department of the Army, Corps of Engineers, Transportation Series, 1 January 1976.

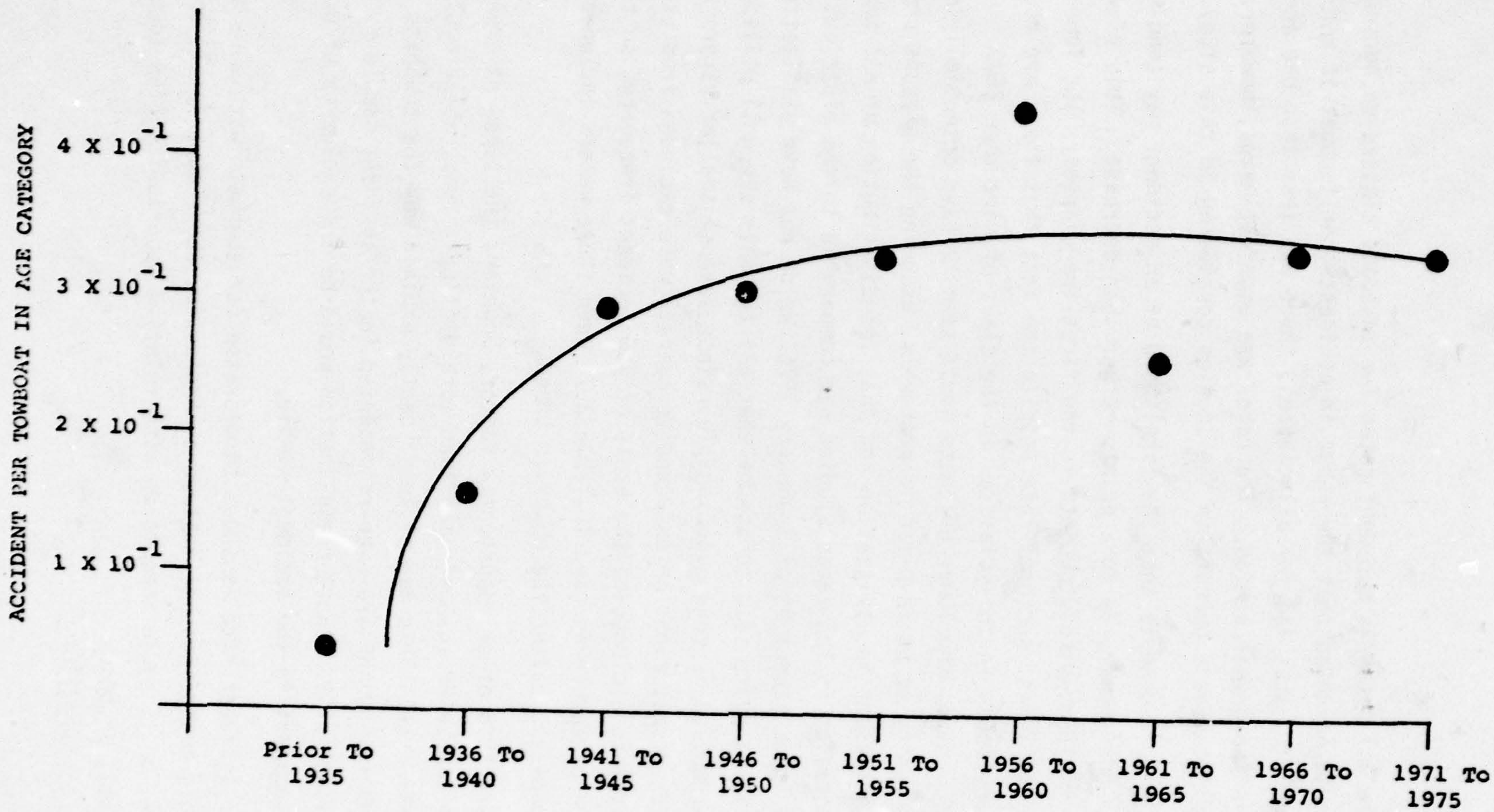

FIGURE 3.10. ACCIDENT RATES FOR TOWBOAT AGE CLASSES

Table 3.7 presents accident rates for towboats classed on horsepower. First, it should be noted that the range in accidents per towboat is very small, 0.2 to 0.7. That is, for all classes, there was less than one accident, per towboat in the 5-year period. The rates are underestimates, however, because not all towboats operate in the locales considered in this study.

Table 3.7 suggests that the likelihood of an accident may tend to increase with horsepower, up to a point, rather than decrease. This view is supported by the numbers of towboats in the first two classes. The lowest HP group has the lowest accident rate despite the fact that there are roughly 8 times as many boats in this class as in the class of more than 2500 HP to 5000 HP. Thus, the lower HP boats would seem to have potentially much greater opportunity to be involved in accidents, assuming the classes are reasonably equivalent in utilization and that the distribution of all towboats that were operating in the areas studied was comparable to the distribution of all towboats in existence as of 1 January 1976. We do not have utilization data, but believe it is quite safe to assume that all towboats are well utilized. The other assumption is more questionable, since several smaller rivers where lower powered vessels might be expected to operate were excluded from study. However, they were excluded on the basis of low accident frequency, so the effect on the picture presented in Table 3.7, were those waters included, should not radically alter the observed trend.

There is another opportunity factor, however, the types of areas worked. The higher HP towboats may take more difficult runs, which would increase their risk. This may at least partly explain why the towboats above 2500 HP to 5000 HP are over-represented in the accident sample by roughly a factor of 3. Another explanation would be the exclusion of certain waters and segments in the accident sample.

The accident rate is shown to decrease for towboats with more than 5000 HP. This could indicate that more horsepower, above some level, has safety value, or it could have to do with relative opportunity (few towboats in that class), or both.

TABLE 3.7

ACCIDENT RATES OF TOWBOATS BY HORSEPOWER CLASS

HP Class	No. of Towboats as of 1 January 1976 [a]	No. of Towboats in Accidents	Accidents Per Towboat in Class
2500 HP or less	1697 (83%)	346 (62%)	.21
> 2500 to 5000	219 (11%)	168 (30%)	.77
> 5000 [b]	140 (7%)	48 (9%)	.34
Total	2056 (100%)	562 (100%) [c]	

[a] Source: Department of the Army, Corps of Engineers, <u>Transportation Series</u>, 1 January 1976.

[b] Upper limit is at 7500 HP, for an interval equivalent to the two lower HP classes.

[c] The total number of towboats in the study sample of accidents is 569. In 7 cases, HP could not be determined.

Horsepower versus load. Table 3.8 gives the average horsepower, HP per loaded barge, and tons per HP of the vessels in accidents at bridges and locks (including "complex" locations with a bridge and a lock in close proximity. The measures of HP versus load show a general constancy across the waterways. The HP/barge ratios, for example, range from 428 to 510, with lower and upper "extremes" of 370 and 564. No interpretable difference is apparent between the types of navigational situation (bridge, lock, or complex).

The vessels in the GIWW accidents tended to have a somewhat higher HP/barge ratio, although they tended to have less power. This is because array size is severely limited by the constraints of the waterway. Similar tendencies are shown for the Illinois Waterway, also highly restricted.

Table 3.9 shows the average number of barges in the accidents at bridges and locks, and demonstrates that the barges typically were loaded.

Table 3.10 gives the average HP per loaded barge and tons per HP of the vessels in accidents that occurred where there was no major structure. The results are similar to those in Table 3.8, except that the ratio of power to load is higher for the groundings where there was no major structure.

The most important finding from these tables is that the measures of horsepower versus load are appreciably higher than was expected based on discussions with towboat personnel. A typically quoted rule of thumb for making up a tow is 250 - 350 HP/barge.

As shown in Tables 3.8 through 3.10, there was a substantial number of cases in which a given vessel characteristic could not be determined. Also, upper and lower extremes are reflected in the averages. Extreme cases were not removed because of the small numbers of cases and the missing observations. Thus the averages shown cannot be interpreted with full confidence. With that caution in mind, the data on horespower versus load indicate that the towboats in the study sample of accidents were not generally underpowered, at least if present views of power sufficiency are accepted.

TABLE 3.8

HORSEPOWER VERSUS LOAD OF VESSELS IN ACCIDENTS AT MAJOR STRUCTURES BY WATERWAY

		Accidents at Bridges	Accidents at Locks	Accidents in Complex Locations (bridge and lock)
Horsepower	Lower Miss.	3550 (31/31)*	-	
	Upper Miss.	3358 (42/43)	2447 (14/14)	2752 (13/14)
	Ohio River	4480 (18/20)	2727 (71/74)	3750 (8/8)
	Illinois River	2630 (55/57)	3680 (6/6)	1914 (8/8)
	GIWW	1144 (84/85)	1392 (17/17)	1870 (4/4)
Horsepower per loaded barge	Lower Miss.	454 (17/31)	-	-
	Upper Miss.	483 (31/42)	436 (11/14)	494 (9/14)
	Ohio River	370 (15/20)	441 (59/74)	460 (8/8)
	Illinois River	496 (31/57)	564 (6/6)	436 (5/8)
	GIWW	510 (72/85)	440 (10/17)	428 (3/4)
Tons per horsepower	Lower Miss.	4.8 (11/31)	-	-
	Upper Miss.	5.6 (17/42)	4.7 (8/14)	3.1 (6/14)
	Ohio River	4.7 (10/20)	4.5 (38/74)	4.4 (3/8)
	Illinois River	3.5 (15/57)	9.0 (4/6)	2.3 (1/8)
	GIWW	3.7 (33/85)	2.1 (3/17)	2.3 (2/4)

* (Number of cases with information/total number of cases in category)

TABLE 3.9

NUMBER OF LOADED AND LIGHT BARGES IN ACCIDENTS AT MAJOR STRUCTURES BY WATERWAY

		Accidents at Bridges	Accidents at Locks	Accidents in Complex Locations (bridge and lock)
Average number of barges	Lower Miss.	12 (25/31)*	-	-
	Upper Miss.	9 (32/42)	9 (12/14)	8 (10/14)
	Ohio River	14 (19/20)	8 (64/74)	9 (8/8)
	Illinois River	7 (38/57)	6 (5/6)	5 (5/8)
	GIWW	3 (78/85)	3 (10/17)	4 (3/4)
Average number of loaded barges	Lower Miss.	10 (22/31)	-	-
	Upper Miss.	8 (29/42)	8 (11/14)	5 (8/14)
	Ohio River	12 (16/20)	5 (59/74)	4 (7/8)
	Illinois River	5 (33/57)	5 (3/6)	2 (4/8)
	GIWW	2 (74/85)	1 (9/17)	4 (3/4)
Average number of light barges	Lower Miss.	3 (22/31)	-	-
	Upper Miss.	1 (29/42)	1 (11/14)	2 (8/14)
	Ohio River	3 (16/20)	3 (59/74)	4 (7/8)
	Illinois River	2 (33/57)	0 (3/6)	3 (4/8)
	GIWW	1 (74/85)	2 (9/17)	0 (3/4)

* (Number of cases with information/total number of cases in category)

TABLE 3.10

HORSEPOWER VERSUS LOAD OF TOWBOATS IN ACCIDENTS AT OTHER LOCATIONS, BY TYPE OF ACCIDENT

	COLLISION WITH MOVING VESSEL (n=70)	RAMMING FIXED OBJECT (n=25)	RAMMING MOORED VESSEL (n=41)	GROUNDING (n=51)	OTHER (n=2)
HP per loaded barge	416 (67) *	542 (22)	481 (40)	654 (38)	253 (2)
Tons per HP	4.1 (3)	2.8 (9)	3.5 (19)	4.3 (27)	No Data

* Number of cases with information

Tow Dimensions. Table 3.11 shows the average length and breadth of the tows in accidents at bridges and locks. The average number of barges is also reported. These averages are based on somewhat different subsets of cases; length was sometimes reported but not breadth, or the reverse. In addition, the problems of missing observations and variance brought up in the discussion of horsepower versus load exist in the data describing tow dimensions as well. Thus again it must be cautioned that the averages taken together are composites which do not necessarily describe a typical tow.

The data in Table 3.11 are arranged so that comparisons between types of accident sites ("Type of Navigational Situation" can be made more readily. It is shown that the tows involved in lock accidents typically are shorter and narrower than those in bridge accidents on the same waterway. This is because of lock dimensions. It is also shown that larger tows tended to be involved in the accidents on the Ohio, as well as on the Lower Mississippi, which is broad and has no locks.

In general, excluding the Lower Mississippi, the data in Table 3.11 suggest that tow dimensions tend to push the limits of the navigation space, as it is economically advantageous to move more cargo per trip. At the bottom of Table 3.11, the margin between tow breadth and bridge span or lock width is suggested to be fairly small except on the lower Mississippi and in the case of bridges on the Ohio. Lock width averaged roughly 1 to 1½ times tow breadth on all waterways and bridge span less than 2 to 2.6 times tow breadth on three of the five waterways. Under these circumstances it could be difficult or impossible to pass another vessel and maintain alignment for the bridge or lock. There also would be little tolerance for changes in position or orientation brought about by current and wind.

It is not known whether the tows in the study sample of accidents tend to be larger than tows which are not involved in accidents. It was not within the scope of this inquiry to collect data on the non-accident population. This is information which ought to be pursued. Conjectures on this topic are included in the study conclusions and recommendations (Section IV).

TABLE 3.11

TOW CHARACTERISTICS IN ACCIDENTS AT MAJOR STRUCTURES, BY WATERWAY

Type of Navigational Situation	Lower Miss.	Upper Miss.	Ohio	Illinois	GIWW
Average Tow Length, ft.					
Accidents at bridges	911 (19/31)	779 (24/42)	1071 (15/20)	810 (26/57)	766 (60/85)
Accidents at locks	-	867 (11/14)	884 (53/74)	1180 (3/6)	732 (8/17)
Accidents in complex locations (bridge and lock)	-	920 (8/14)	959 (6/8)	771 (4/8)	937 (2/4)
Average Tow Breadth, ft.					
Accidents at bridges	121 (18/31)	109 (24/42)	130 (14/20)	85 (28/57)	49 (50/85)
Accidents at locks	-	98 (10/14)	92 (52/74)	71 (3/6)	48 (7/17)
Accidents in complex locations (bridge and lock)	-	87 (8/14)	100 (6/8)	85 (5/8)	44 (2/4)
Ratio of Bridge Span or Lock Width to Tow Breadth					
Accidents at bridges	7.3 (16/31)	1.9 (21/42)	5.3 (12/20)	1.7 (20/57)	2.6 (33/85)
Accidents at locks	-	1.2 (10/14)	1.2 (51/74)	1.5 (3/6)	1.5 (7/17)
Accidents in complex locations (bridge and lock)	-	1.5 (7/14)	4.5 (6/8)	1.1 (4/8)	-

OPERATOR CHARACTERISTICS

The pilot of a towboat is the man at the wheel, and is the only one on duty in the pilot house.[3] Unlike the person-in-charge on a deep draft vessel, a towboat pilot is the sole controller, navigator, and communicator. At times he is a very busy man. He single-handedly controls hundreds of horsepower and thousands of tons of cargo in as many as 40 barges under a variety of physical and environmental conditions.

The variables that affect human competency, and their relationships, are not fully understood. The parameters of talent for pilotage may include visual and aural acuity, IQ, imagination, sense of relative motion, the way in which the brain's alertness center function, nervous system response to sustained and sudden stress and other more or less stable pychophysiological traits, plus a body of acquired skills and knowledge which are built up largely through experience. Although these traits may be more or less constant over time, they are believed to be alterable by transient conditions, including both personal and environmental states. Virtually no data are available for use in assessing the associations between accident occurrence and operator personal characteristics as they may be affected by circumstances. The accident report forms ask for information about only three possible gross indicators of pilot personal capabilities: age, experience, and time on watch. This section describes trends with regard to those variables in the study sample of data.

Age and Experience

It has been suggested that accidents happen to the young and inexperienced pilots and also to older pilots whose perceptual capabilities and reaction time may be reduced. We were told it is a saying on the rivers that "the young pilot goes into a situation too fast and knows it and the old pilot goes into a situation too slow and knows it." However, extremes of age were not observed among the pilots involved in the accident sample in this study. In general, the typical pilot was in his late thirties to mid-forties. Accordingly, the pilots typically had substantial experience--from 10 to 20 years.

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[3] "Pilot" is the title given the second in command on a towboat. The pilot alternates watches with the captain. However, the term pilot is used here to mean the person in charge of pilotage, including both.

Table 3.12 presents the age and experience results by waterway and type of navigational situation (e.g., bridge passage). Little variation is indicated. The average for "complex situation" accidents on the GIWW is notably lower, but there were only four such accidents on the GIWW. Similarly, young and inexperienced pilots are shown to be typically involved in groundings on the Illinois Waterway, but there were only four cases in that category.

Table 3.13 presents age and experience results for all collisions and rammings that did not occur at bridges, at locks, or in complex situations as defined in Table 3.12.

It can be conjectured that pilots in their middle years may make up the majority of working pilots, giving the middle age group more opportunity for accident involvement. It can be conjectured that young and inexperienced pilots may not be on watch for the difficult passages during which the accidents in the study sample occurred. That being the case, the younger group would be less likely to be involved in accidents than their relative numbers might indicate. It can be conjectured, similarly, that pilots beyond their middle years may tend to work less frequently or make shorter runs, giving the older age group less opportunity for accident involvement. It was not possible within the scope of this study to gather the kinds of information needed to explore these possibilities.

It can be said that it is not young and inexperienced pilots or old pilots who are having the majority of the accidents. Age/experience could still be found to be an indicator of accident potential if it were possible to control for opportunity. Even so, age/experience might be given lower priority than other types of problems, on the grounds of magnitude and limited safety program resources. This assumes that middle-age-group personnel are not overrepresented in accidents.

TABLE 3.12

OPERATOR AGE AND EXPERIENCE, BY WATERWAY AND TYPE OF NAVIGATIONAL SITUATION

Operator Characteristic	Lower Miss.	Upper Miss.	Ohio	Illinois	GIWW
All Accidents at Bridges					
Average age	44 (79%)[a]	44 (71%)	43 (85%)	41 (77%)	39 (80%)
Average years of experience	17 (58%)	20 (67%)	16 (70%)	14 (54%)	13 (54%)
All Accidents at Locks					
Average age	No accidents	41 (79%)	46 (85%)	40 (83%)	40 (94%)
Average years of experience		11 (57%)	17 (64%)	7 (50%)	15 (35%)
All Accidents in Complex Situations[b]					
Average age	No accidents	38 (79%)	46 (100%)	44 (88%)	30 (50%)
Average years of experience		12 (50%)	14 (75%)	10 (50%)	9 (50%)
Other Groundings[c]					
Average age	41 (1 case)	42 (67%)	47 (67%)	30 (100%)	36 (91%)
Average years of experience	7 (1 case)	15 (39%)	20 (17%)	4 (100%)	9 (77%)

[a]Number in parentheses is percentage of cases with information.

[b]Area in which there is both a bridge and a lock in close proximity.

[c]All groundings that did not occur in any of the preceding navigational situations.

TABLE 3.13

OPERATOR CHARACTERISTICS FOR COLLISIONS AND RAMMINGS THAT DID NOT OCCUR AT MAJOR STRUCTURES

Operator Characteristic	Collision with Moving Vessel	Ramming, Fixed Object	Ramming, Moored Vessel
Average age	40 (84%)[a]	39 (92%)	41 (83%)
Average years of experience	14 (74%)	13 (68%)	17 (78%)

[a] Number in parentheses is number of cases with information.

Table 3.14 lists the numbers and percentages of accidents that occurred at given hour intervals in the normal 6-hour watch cycle for all five waterways. The data indicate that accident occurrence is relatively evenly distributed over the watch period. This disputes the commonly held belief that the pilot just coming on watch is more accident prone because he is not fully awake and/or not "up to speed." Another commonly held belief is that fatigue sets in toward the end of the watch and the pilot's perceptual capabilities are duller, his reactions slower, or both. There is no evidence to support this supposition either. If anything, Table 3.14 suggests that accidents might be somewhat less likely in the first and last hours of the watch. However, the data are not conclusive on that, considering the number of missing observations.

TABLE 3.14

HOURS ON DUTY WHEN ACCIDENT OCCURRED

(All Waters)

Hours	No. of Cases	% of Cases
0 - 0.9	42	12
1.0 - 1.9	59	17
2.0 - 2.9	69	20
3.0 - 3.9	55	16
4.0 - 4.9	64	18
5.0 - 5.9	50	14
6.0	6	2
7.0	1	-
8.0	0	0
9.0	2	1
10.0	1	-
Total	349	100% (61% of total sample)

CAUSAL FACTORS AS STATED IN THE ACCIDENT REPORTS

In most cases the accident reports include some description or statement as to causal factors. The towboat pilot provides a brief narrative (usually one or two sentences) describing the accident and stating what caused it. This is followed up by a Coast Guard investigator, who usually adds to the pilot's brief statements based on his review of the case.

Approach to Causal Data Analysis

The causal inferences contained in the reports were extracted and recorded on the explanation sheets accompanying the charts on which accident locations were plotted (see Appendix C). Causal statements were recorded for each accident by mile segment and waterway. This resulted in a considerable list of words and phrases, many of which are highly similar. For example, phrases such as "current set tow," "strong outdraft," "cross current," all pertaining to current as a source of difficulty, were very frequently found in the reports.

Then tallies were made of the numbers of times identical or highly similar causal phrases and words were used. This was done separately for collisions, rammings, and groundings. Combinations were made, resulting in shorter lists of "causal factors." At this point there were 11 collision factors, 22 ramming factors, and 14 grounding factors. Finally, the lists were compared to categories of task performance requirements and environmental factors that impinge on safe navigation, as specified in the previous task analysis of vessel control in towboat-barge operations on the inland waterways.[4]

[4] J. Smith et al., Task Analysis of Vessel Control, Volume III, Silver Spring, Maryland: ORI, Inc., December 1976. U.S. Coast Guard Report No. CG-D-1-77, NTIS AD A037316.

The presentation of findings from the causal factor analysis is organized as follows. First the performance requirements as defined in the task analysis of vessel control are reviewed. Then, for each accident type, in turn, the causal factors identified in this study are presented and discussed in relation to the performance requirements.

Requirements for Vessel Control in Towboat-Barge Operations

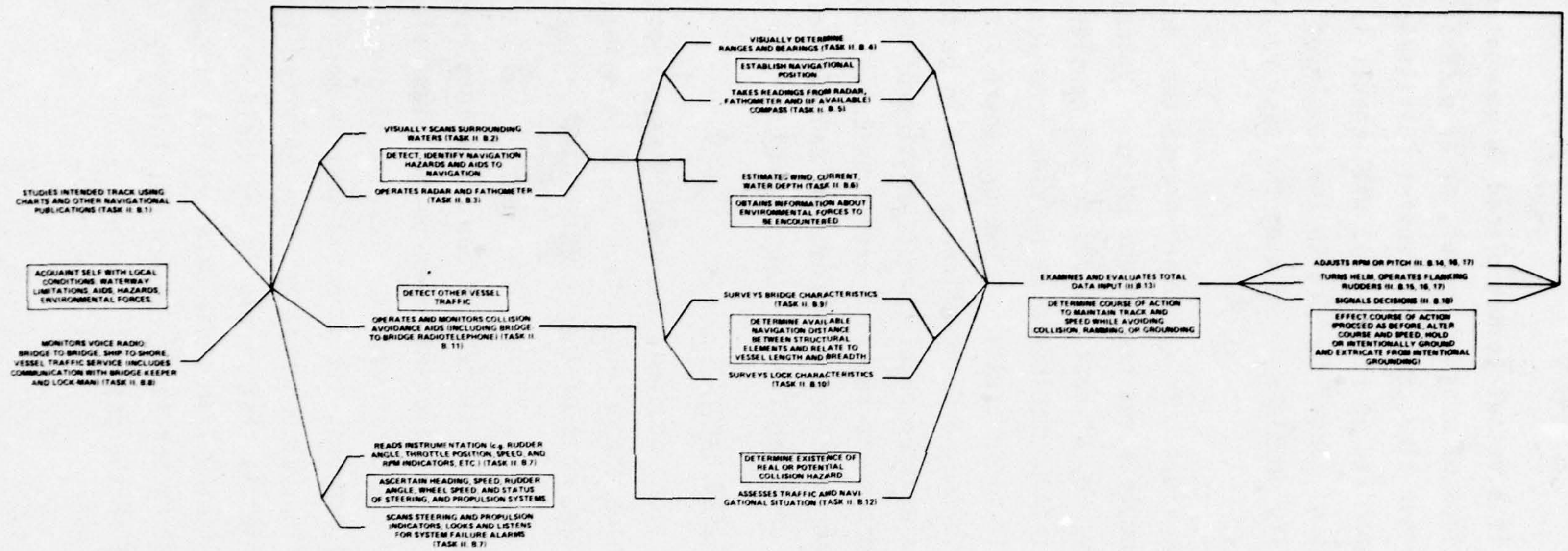
Figure 3.11 is a schematic of the flow of tasks in tow navigation in restricted areas, drawn from the previously cited task analysis. It can be seen from the figure that there are three main kinds of tasks involved:

- Information gathering
- Information synthesis and decision-making
- Output or execution.

The task flow continuously repeats itself and often several tasks are done so closely together in time that they are essentially simultaneous. Some -- for example, the "examine and evaluate" task and the visual scanning of surrounding waters (including scanning by radar as required) -- may be viewed as continuous in effective vessel control.

It should also be noted that the "total data input" considered in the examine and evaluate task typically exceeds by far the information available from external sources in present time. Towboat pilotage, in fact any pilotage, depends greatly on stored knowledge and imagination of contingencies. Excellent documentation and discussion of these inputs to vessel control are contained in an observational and self-report study of pilotage in confined waterways.[5]

[5] J. Huffner, Pilotage in Confined Waterways of the United States: A Preliminary Study of Pilot Decision-Making. Linthicum Heights, Maryland: The Maritime Institute of Technology and Graduate Studies, July 1976. U.S. Coast Guard Report No. C6-D-96-76, NTIS AD A029715.



NOTE: BOXED STATEMENTS SUMMARIZE THE RESULTS EXPECTED FROM VESSEL CONTROL TASKS. THE STATEMENTS ABOVE AND BELOW THE BOXED STATEMENTS SUMMARIZE "TASK ACTION REQUIREMENTS." REFERENCES ARE GIVEN TO THE COMPLETE TASK STATEMENTS IN THE VESSEL CONTROL TASK ANALYSIS, VOLUME II (APPENDIX G: FUNCTIONAL JOB ANALYSIS TASK STATEMENTS FOR TOWBOAT CAPTAIN OR PILOT) U.S. COAST GUARD REPORT NO. CG-D-1-77, NTIS AD A037 442. THE ROMAN NUMERAL II REFERS TO THE FUNCTIONAL GOAL SERVED BY THE TASKS. FOR THIS ILLUSTRATION A SINGLE GOAL WAS CHOSEN: "NAVIGATE THROUGH (MANEUVER IN) RESTRICTED WATERS AS REQUIRED IN ORDER TO REACH DESTINATION SAFELY AND EXPEDITIOUSLY." (A BERTHING/UNBERTHING GOAL WAS ALSO STATED, WITH MANY TASKS IDENTICAL OR SIMILAR TO THE NAVIGATION GOAL. A THIRD GOAL WAS ALSO SPECIFIED–SUPERVISION AND TRAINING OF TOWBOAT PERSONNEL.) THE LETTER "B" IN THE TASK ID (e.g., TASK II. B.1) REFERS TO THE FUNCTIONAL OBJECTIVE SERVED BY A SUBSET OF TASKS. THE OBJECTIVE USED FOR ILLUSTRATION IS TO "IDENTIFY AND RESPOND TO POTENTIALLY HAZARDOUS CONDITIONS IN ORDER TO AVOID COLLISION, RAMMING OR GROUNDING, WHILE SIMULTANEOUSLY MAINTAINING POSITION WITHIN THE LIMITATIONS OF THE RESTRICTED WATERWAY." SEE PAGE 11, VOLUME I, OF THE CITED REPORT.

FIGURE 3.11. FLOW OF TASKS IN TOW NAVIGATION

It is assumed that if a vessel is not placed in unusual jeopardy by a mechanical problem, actions of another vessel, or an excessive environmental disturbance of some other kind, then successful fulfillment of the set of task requirements summarized in Figure 3.11 will result in effective vessel control. The analysis of causal factors in the sample of accidents in this study seeks to identify problems in meeting the task requirements and reasons for such problems.

The accident reports limit this endeavor because they do not address task problems on a complete and consistent basis. Typically they describe accident consequences or, at best, allude to the results of task performance problems. Thus interpretations must be made from scanty causal information that is, in itself, interpretive. However, there are strong trends in the causal factors cited, and those trends seem to be supported by the analysis of vessel and environmental characteristics of the accident situations. Thus causal findings are reported with substantial confidence. Although they do not go as deep as might be hoped, the causal analysis results do identify major sources of unreliability in tow control.

Causal Factors Cited in Collision Reports

In most of the collisions studied, the vessels were meeting head-on (about 90% of all cases in which the determination could be made). About 70% (65) took place on the GIWW, most of them (82% of GIWW collisions) at a bend or intersection.

The most frequently cited task-related causal factors were vessel-to-vessel communication problems, failure to keep to the right side of the channel and late detection of the other vessel. Table 3.15 gives the rank order of factors cited in the reports. It is noted that in most cases only one causal factor was identified, although it has been observed in working with more detailed accident reports that rarely is any accident situation so simple as this implies. Missing from these data are the circumstances that underlie the cited causal factor (e.g., we are not told why the vessel failed to keep the right side of the channel).

TABLE 3.15

RANK ORDER OF CAUSAL FACTORS CITED
IN COLLISION REPORTS

1.	Vessel-to-vessel communication problems		19(21%)*
	a. No or late communication	14(16%)	
	b. Mix-up in information, broke agreement	5(6%)	
2.	Failure to keep to right side of channel		16(18%)
3.	Late detection		15(17%)
	a. At a bend or intersection	9(10%)	
	b. Poor visibility, shore lights, other vessel improperly lighted	5(6%)	
4.	Current or suction caused sheer		15(17%)
5.	Mechanical problem		8(9%)
6.	Other vessel(s) (not directly involved in the collision) or obstacle(s) limited maneuvering options/had to be avoided		5(6%)
7.	Channel too narrow for passing		4(4%)
8.	Shallow water reduced control		4(4%)
9.	Wind sheered vessel		3(3%)
10.	No explanation given		3(3%)
11.	Insufficient HP, problem with assisting vessel		2(2%)

* Percentage of cases in which factor was cited. No. of cases = 90. More than one causal factor was recorded in 4% of the cases.

Communications Problems
(Task Reference: II.B.8)

Among the potential types of communication problems, the predominant problem (about three-fourths of the communications-related cases) was failure to undertake an exchange-- either no communication or too late to allow for action. The numbers involved are small, but it seems worth noting that in about 70% of these cases the accident occurred at a bend or intersection; it may be that the other vessel was not seen. The bridge-to-bridge radiotelephone regulations (PL 92-63) suggest, but do not require, that a broadcast call be made when approaching a blind situation to find out whether an unseen vessel is approaching and agree as to how to assure a safe encounter.[6] It should be noted that in some of these cases a call may have been made by one vessel but not heard or returned. Towboat personnel say they consider it prudent practice to make broadcast calls but that it cannot be taken for granted that no answer means the way is clear. The study data are not detailed enough to distinguish not listening from deciding that communication is unnecessary and from problems in effecting communication.

The percentage of all collision cases involving a communication problem is consistent with findings in a previous study in which the effectiveness of bridge-to-bridge radiotelephone was evaluated through time series analysis.[7] A significant decline was observed after the introduction of the device, in accidents that might have been prevented by its use. After a drop of about 20% in the incidence of such accidents, their incidence held roughly constant for three years, FY 1972 through FY 1974, which was the final year of the study period. The residual percentage of collisions that might have been prevented by use of bridge-to-bridge radio was 19%. This is approximated by the present study findings of 21% over the period FY 1972 through FY 1976. This suggests that the safety gains made are not being lost and that further gains may require modification of the existing regulations.

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[6] U.S. Coast Guard, Bridge-to-Bridge Radiotelephone Communications Laws and Regulations, CG 439, 1 December 1972.

[7] L. Stoehr et al., Spill Risk Analysis Program: Methodology Development and Demonstration, Volume I. Silver Spring, Maryland: ORI, Inc., May 1977. U.S. Coast Guard Report No. CG-D-21-77, NTIS AD A037316.

Failure to keep to right side of channel
(Task Reference: II.B.4-II.B.6, II.B.13-15)

In most of these cases it was not clear why the vessel failed to keep to the right side. However, most of the collisions occurred on the narrow GIWW, where the pilot has to keep in mind possible suction effects and where minor current and wind effects may be enough to tip the balance from safe passing to a collision. The greater difficulty of control in rounding a bend is certainly implicated. Other concerns such as aligning for an upcoming bridge or lock, or to avoid some hazard along the bank, may figure in failure to stay to the right, or it may simply be a matter of not attending carefully enough to vessel position and orientation.

In the terminology of the task analysis, these cases may be categorized as failures to establish position or as failures to maintain proper position, whether influenced by environmental forces, concern for other hazards, failure to evalute the requirements of the navigational situation, faulty execution of navigational decisions, or some combination of these possible performance problem areas. The discussion of cases in which environmental forces were identified as causal factors is most probably pertinent to a number of cases of failure to keep to the right even though environmental forces were not mentioned.

The differences between the cases of failure to stay to the right and those in which the channel was said to be too narrow for passing are not clear. The latter statement implies that passing was entirely infeasible, but the cases did not occur in a one-way channel, althought there may have been obstacles temporarily reducing the navigable area. Even when passing is feasible, it may require considerable precision such that there is little tolerance for even a minor external disturbance or "error" in control judgment or action. Such situations are not uncommon on the GIWW and in the canals on the Ohio River and the Illinois Waterway.

Position-fixing in the sense of establishing the mile-point along the waterway does not appear to be a significant problem area; it is difficult not to know your position in a highly restricted area. In general, position is infrequently established in the textbook sense. More often this task is done by estimate,

based on direct observation of reference points. Greater precision and frequency of this task might be helpful, but would not be easy for the lone pilot to accomplish. Equipment deficiencies and insufficient training/experience may be reducing the effectiveness of radar navigation or causing it to be avoided.

Finally, the precision of input information and control possible, given today's technology, is insufficient to guarantee 100% reliability in passings in highly confined areas. Thus, these accidents are believed to be situationally caused, primarily, although inattentiveness to the hazards of the situation is not ruled out.

Late Detection
(Task Reference: II.B.2, II.B.8, II.B.11)

Late detection is the third most frequently cited collision causal factor, identified in 18% (16) of the cases. These detection failures seem to have had, consistently, strong situational components. The encounter was at a bend or intersection (9 cases) or there was some other environmental condition (poor visibility, shore lights) that interfered with seeing the other vessel (4 cases) or some attribute of the other vessel made it hard to detect (1 case). Late detection at a bend (or intersection, depending on shore features) brings up the matter of broadcast calls discussed in the context of communication problems. There were six late detections in which some impediment to vision was identified as an underlying factor. The number of cases is small, but it appears that they might have been avoidable by use of radar.

Current, Suction Effects, Wind, Shallow Water
(Task Reference: II.B.1, II.B.2, I.B.3, II.B.6)

In the cases in which these factors were cited, the functional objective to maintain position was not accomplished. The reports clearly indicated that environmental forces affected vessel control, whereas in most of the cases in which failure to keep to the right was cited, no environmental force was implicated.

Maintenance of position against environmental forces depends first on information about the forces acting upon the vessel (we include water depth in this category for the present purpose). Moreover, that information is needed in advance because of the time lag between a control change to compensate for the force (say, current) and the vessel's response. There is rarely any source from which accurate information about present current and wind direction and speed can be obtained in advance. Towboats are equipped with fathometers (to measure water depth) and often with mechanical indicators of wind direction and speed. However, they measure what the array is going through or over at the moment, so that the information is too late to be of much utility. Navigational references provide estimates based on history. Other vessel operators who have been through an area or (in a few areas) the vessel traffic service, may provide advance warnings, but they will not be precise. Most of all, the pilot relies on his own experience and observations to make estimates and projections. Thus, the accuracy and timeliness of input information are believed to be key factors underlying failures to maintain position.

Another key aspect of this performance problem area is uncertainty about the vessel's response, given the dimensions of the tow, the amount and kinds of cargo being transported, the direction of passage, and channel contours as well as atmospheric and water conditions. There are no formulas to determine the right control adjustments for given values of all those variables. Again, experience is relied upon heavily. Pilots have commented that each trip is an adventure, even though they tend to work the same route for years.

Given the limitations of the input data and uncertainty as to vessel response, it is a small wonder that maintenance of position (and orientation) should be observed as a problem area in collisions in highly restricted areas.

Collisions attributable to loss of control in the presence of all forms of environmental disturbance total 22, or 24% of the total number of collisions studied. Thus in total this is a problem area equivalent in magnitude to communications. Depending on the number of cases in which

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HUMAN AND PHYSICAL FACTORS AFFECTING COLLISIONS, RAMMINGS, AND --ETC(U)
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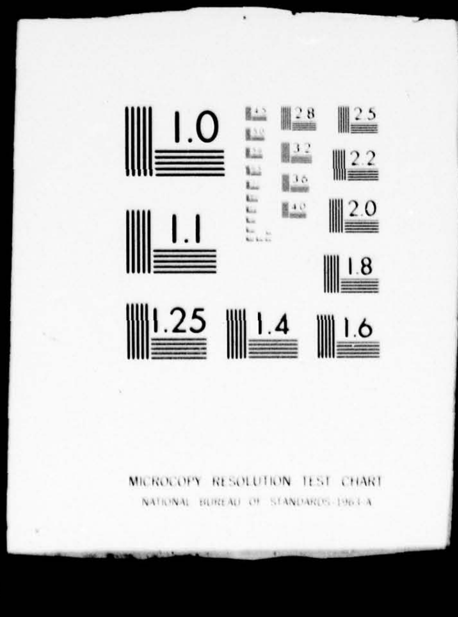


failure to keep to the right was influenced by environmental forces, this could be the largest problem area in the tow-barge collisions, as it is in the rammings and groundings. Current was the most frequently cited disturbing force in all three types of accidents.

It was noted that most of the collisions took place on the GIWW. There, current is not always a factor. It can have strong effects, however, at intersections with a river or with a sea/harbor entrance channel. In addition, outdrafts at locks must be considered.

Other Vessels or Obstacles
(Task Reference: II.B.1-3, II.B.8, II.B.11 and 12, II.B.13)

There were five cases in which the necessity to avoid another vessel (not the other vessel in the collision) or some other obstacle was cited as an accident factor (for example, a moored barge, a ship swinging on its anchor, or remains of an old lock). The pilot may have been preoccupied with this problem so as not to recognize the collision threat in time, or he may have had no way to avoid both threats. The task problems leading to an accident of this kind may be in information gathering, i.e., detecting the situation soon enough to avoid it (Tasks II.B.1-3 and II.B.8); in assessing the threats and deciding on a course of action (Tasks II.B.11 and 12 and II.B.13); or in effecting the course of action (Tasks II.B.14 and 15).

As in the case of environmental disturbances, the sources of information are not sure and neither are the outcomes of control changes for collision avoidance, especially when the situation arises in or near a bend. There is also the possibility of confusion from too many variables to be weighed at once. This could result in decision delays, poor decisions, or both. Finally, task performance may be irrelevant - there may be no way to avoid an accident given the situation.

Mechanical Problems and Other Problems Associated with the Vessel Itself

Just under 10% of all collisions were attributed to mechanical problems, most often broken line so that a barge got loose or the tow broke up.

There was one case in which the investigating officer concluded that the towboat horsepower was insufficient for the load and one in which an assisting vessel struck a barge.

Causal Factors Cited in Ramming Reports

Table 3.16 shows that current was the most frequently cited causal factor in the ramming cases. An explicit reference (current, high water, flood stage, tide, outdraft, etc.) to current effect as a cause was made in just over 40% of the reports. The second most frequent factor was wind, cited in 16% of the ramming reports. There were additional cases (11%) in which the causal statement was "out of shape" or "lost control," with no comment about underlying factors. The wind and out-of-shape/lost-control categories overlap some with the current category, but usually only one of the three factors was cited. It is reasonable to assume that in most of the out-of-shape/lost-control cases, current or wind was involved. Thus, on the order of 60% of the rammings were attributed to control problems in the presence of disturbing environmental forces (if 23% of the cases in which current was cited are assumed to have had another factor cited as well).

The problems represented in these cases may be categorized with respect to personnel performance (Figure 3.11) as:

- failure to detect or identify the hazard ("identify" here means to determine precisely the speed and direction of impinging forces and their potential effect on the vessel, to determine the specific identity of an aid, etc. - i.e., to pin down the nature of what is seen. (Task Reference: Task II.B.6, supported by II.B.1-5 and II.B.7-10.)

TABLE 3.16
RANK ORDER OF CAUSAL FACTORS CITED IN THE RAMMING REPORTS

1.	Current, high water, flood stage, tide, outdraft	158	(41%)*
2.	Wind	62	(16%)
3.	Out of shape, lost control	43	(11%)
4.	Fog, poor visibility, shore lights vessel improperly lighted	30	(8%)
5.	Mechanical problem	29	(8%)
6.	Problem in tow (e.g., light tow, large tow, insufficient HP, etc.)	20	(5%)
7.	Problem with bridge, lock or aid (e.g., light out, bridge fender missing, bridge failed to open, no lockman, lockman error)	18	(5%)
8.	Complex situation, other vessel(s) limited maneuvering options/had to be avoided	18	(5%)
9.	No explanation given (one implausible)	15	(4%)
10.	Misjudged stopping distance	12	(3%)
11.	Failed to detect or identify hazard	11	(3%)
12.	Excessive speed for circumstances	9	(2%)
13.	Navigated too close, suction, misjudged channel width	8	(2%)
14.	Docking maneuvers, making up tow, problem with assisting vessel	8	(2%)
15.	Limited maneuvering room	7	(2%)
16.	Inexperienced person in charge, poor navigational judgment	5	(1%)
17.	Poor radar, poor use of radar	4	(1%)
18.	Problem in communication with lookout, lookout did not report	4	(1%)
19.	Tow surged in lock	4	(1%)
20.	Ice	4	(1%)
21.	Submerged/uncharted hazard, sand bar, silting	3	(<1%)
22.	Low water	1	(<1%)
		473	

*Percentage of cases in which factor was cited, N of cases = 385. More than one factor was recorded in 23% of the cases.

- failure to evaluate the hazard and make a correct choice of compensating action (Task II.B.13)
- failure to maintain position -- i.e., effect control (Tasks II.B.14-17)

Failure to effect control may be viewed as attributable to faulty execution or lack of the means to effect control, when the hazard was known and a proper decision made. The reports provide no indications of faulty execution but do include instances in which the pilot lacked the means of control, as follows.

Cases were distinguished in which the horsepower was judged by the investigating officer to be insufficient and others in which the tow size was indicated to cause control difficulty. Problems of this kind were identified in fewer than 5% (20) of the cases. (Light tow was included in the category of "problems with tow" but does not necessarily indicate lack of means of control.) Mechanical problems including engine and steering malfunctions and broken lines were identified in 8% (29) of the cases. There may well have been additional cases in which the means of control were inadequate. Powering requirements for different operating conditions are not well established, as previously discussed. However, based on the information available in the reports, insufficient control capability was a problem in a relatively small percentage of the cases -- on the order of 10%.

The differentiation of detection/identification problems from evaluation/decision-making problems is difficult. However, the relevant task specifications clearly indicate that for certain kinds of hazard, detection and identification, particularly the latter, are open to a large degree of uncertainty. As previously discussed, there is no source of precise, advance input on current and wind; moreover, the effects of these variables on a particular vessel configuration are not well established.

It is believed that the most likely major source of difficulty in maintaining position in the face of environmental forces is the inadequacy of information about the forces and their effects. When there is little room for deviation, as in a bridge passage, lock approach, narrow channel, or con-

gested area, rammings would appear to be inevitable just by the laws of chance. As previously shown (from Table 3.3), 83% of the rammings studied occurred at a bridge or lock. Usually the bridge or lock itself was struck; in a few cases a nearby structure or moored/grounded vessel was struck. In a large number of these cases the structure was near a bend or intersection where cross currents and cross winds cause vessels to slide or sheer. Current anomalies also occur around bridge piers and at locks.

Other Kinds of Detection/Identification Problems

There was another group of cases involving problems in the detection function when the hazard was an object — usually another vessel, also a structure such as a dike, and in one case an aid to navigation. In 11 of these cases (3% of all rammings), failure to detect or identify the hazard was explicitly indicated in the report. In 30 cases (8% of the rammings), visibility factors were cited (e.g., fog, poor visibility, shore lights). In 4 cases (1%), there were problems in communication with a lookout, or the lookout reported no hazard. At least in the visibility cases, effective use of radar might have prevented the casualty and radar use might be considered an underlying factor; however, poor radar and poor use of radar were identified in only four cases (1% of all the rammings). A submerged/uncharted hazard, a sandbar or silting, posed detection problems in 3 cases (< 1% of the total). It is noted that, even if these were mutually exclusive cause categories, which they are not, together all of the "other detection problems" cases comprise about 12% of the rammings -- a small problem area compared to that of maintaining position.

All other categories and plausible combinations of categories were identified in fewer than 5% of the cases.

Causal Factors Cited in Grounding Reports

In the groundings, like the rammings, the major performance problem area was maintenance of position and the major single underlying factor recorded was current. Most of the groundings occurred in or near a bend or intersection.

For the groundings accident type too, the source of the position maintenance problems is believed to have been lack of timely and accurate information about the forces encountered, and ambiguity about their effects

on the vessel and, therefore, uncertainty about the degree and timing of compensatory control actions.

Table 3.17 shows the rank order of individual factors in groundings. Combining current and wind (identified in 32% and 9% of the cases, respectively) just over 40% of the cases involved control problems stemming from the action of environmental forces. There were additional cases (item 7 in Table 3.17) explained by "lost control" or "out of shape" (usually in a bend) without mention of current or wind; but it is reasonable to assume that one or both forces were involved. The same applies to the "light tow, large tow" cases (item 8 in the table). Adding those cases, the overall category of control problems stemming from environmental forces applies to about half of all groundings.

The other substantial categories are:

- navigated too close to shore, suction, failure to keep to the right -- cited in 14% of the groundings (13 cases)
- other vessel(s) or obstacle(s) limited maneuvering options/ had to be avoided -- 13% (12 cases).
- submerged/uncharted hazard, sandbar, silting -- 13% (12 cases).

The first of these other categories in particular may have involved external forces as contributing factors. Questions about precision in determining position and also about attentiveness might also be raised.

Low water was identified as a factor in only 6% (7) of the cases. All other factors were identified in fewer than 5% of the cases.

TABLE 3.17

RANK ORDER OF CAUSAL FACTORS CITED
IN THE GROUNDING REPORTS

1.	Current, high water, tide	29(32%)*
2.	Navigated too close to shore, misjudged channel width, bank suction, narrow channel	13(14%)
3.	Other vessel(s) or some other obstacle(s) limited maneuvering options/had to be avoided	12(13%)
4.	Submerged/uncharted hazard, sandbar, silting	12(13%)
5.	Wind	8(9%)
6.	Low water	7(8%)
7.	Out-of-shape, lost control	5(6%)
8.	Light tow, large tow	5(6%)
9.	No explanation	5(6%)
10.	Mechanical problem	4(4%)
11.	Docking maneuvers making up tow	3(3%)
12.	Got stuck after intentional grounding	2(2%)
13.	Fog, poor visibility, night	2(2%)
14.	Excessive speed	1(1%)
		108

* Percentage of cases in which factor was cited. No. of cases = 91. More than one factor was recorded in 20% of the cases.

TYPICAL ACCIDENT SCENARIOS

The analysis examined individual parts of the vessel control system. Single variables representing the human operator, vessel and environment were examined across many instances of vessel control failure, so that commonalities or trends might be discerned.

The preceding subsections have been devoted to describing the trends observed in individual variables. The purpose of this section is to clarify the significance of those pieces of information, and bring the results as a whole into better focus, by using them in examples of accident processes.

The examples are called "typical accident scenarios." They set forth typical situations using the personnel, vessel, and environmental conditions most frequently observed in the data. Then they describe event sequences wherein vessel control is lost, based on the causal factors most frequently cited in the accident reports. Each scenario or set or scenarios is preceded by a review of the previously presented analysis findings which support it.

Tendencies in Collision Characteristics

- Collisions of two moving vessels comprise 16% of all accidents studied. These are the collisions which occurred in locations of high accident frequency. Others were disperced over the waterways.

- Seventy-two percent of the collisions studied occurred on the GIWW-West. This amounts to 65 collisions in a 5-year period which occurred on 100 miles of waterway. All of these collisions occurred in a very narrow channel and/or at a bend or intersection.

- Ten collisions (11%) occurred on 40 miles of Lower Mississippi, eight of them in or near bends.

- The average age of the pilots in these cases was 40, and they averaged approximately 14 years of experience.

- The average number of hours on duty at the time of the accident was 2.6.
- The horsepower per barge ratio of the vessels in all collisions studied was 416. The ratio tended to be higher although the horsepower of the towboats was relatively low, because few barges were being moved.

Figures 3.12 and 3.13 illustrate the kinds of situations in which the collisions in the study sample typically occurred.

Collision Scenarios

Two vessels are approaching a bend on the GIWW-West from opposite directions. One is a 2000 horsepower towboat pushing four barges and the other is a 1000 horsepower boat pushing two barges. One operator is age 35, with 7 years of experience. The other is 41, with eleven years of experience. Both are familiar with the area.

Neither pilot makes a station call. The larger vessel reaches the bend first. In rounding it, the tow moves toward the center of the channel. The pilot of the smaller vessel is navigating very close to the bank on his approach to the bend; he has just passed an intersection with a canal, from which another vessel was exiting. As the two tows pass, suction is created, pulling the lead barge of the smaller tow into the larger towboat. Figure 3.12 illustrates this situation.

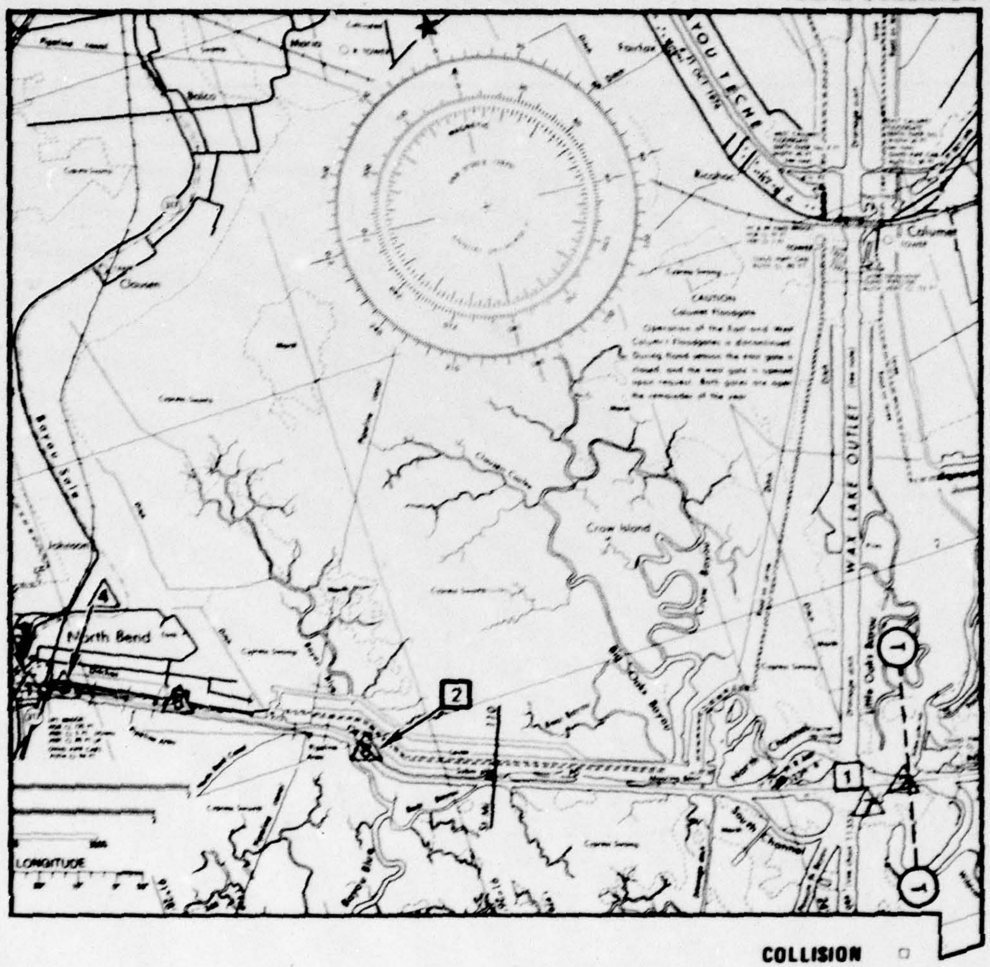
\- OR -

The vessels are approaching a junction of the Intracoastal Waterway with a river. The pilots have communicated and agree that they can proceed for a safe passing. The smaller tow enters the bend first, from the GIWW, eastbound. The tow is affected by the river current, and cannot get over to the right side of the river channel as quickly as anticipated on coming out of the bend. The westbound tow does not have time to take effective avoidance action. Figure 3.13 illustrates this situation.

\- OR -

MILE SEGMENT 100 (105-115)
GULF INTRACOASTAL WATERWAY—WEST
(Chart 11350)

BEND COLLISION



COLLISION □
RAMMING △
GROUNDING ○

FIGURE 3.12. COLLISION SCENARIO
(Note collision number "2" : $\boxed{2}$)

JUNCTION COLLISION

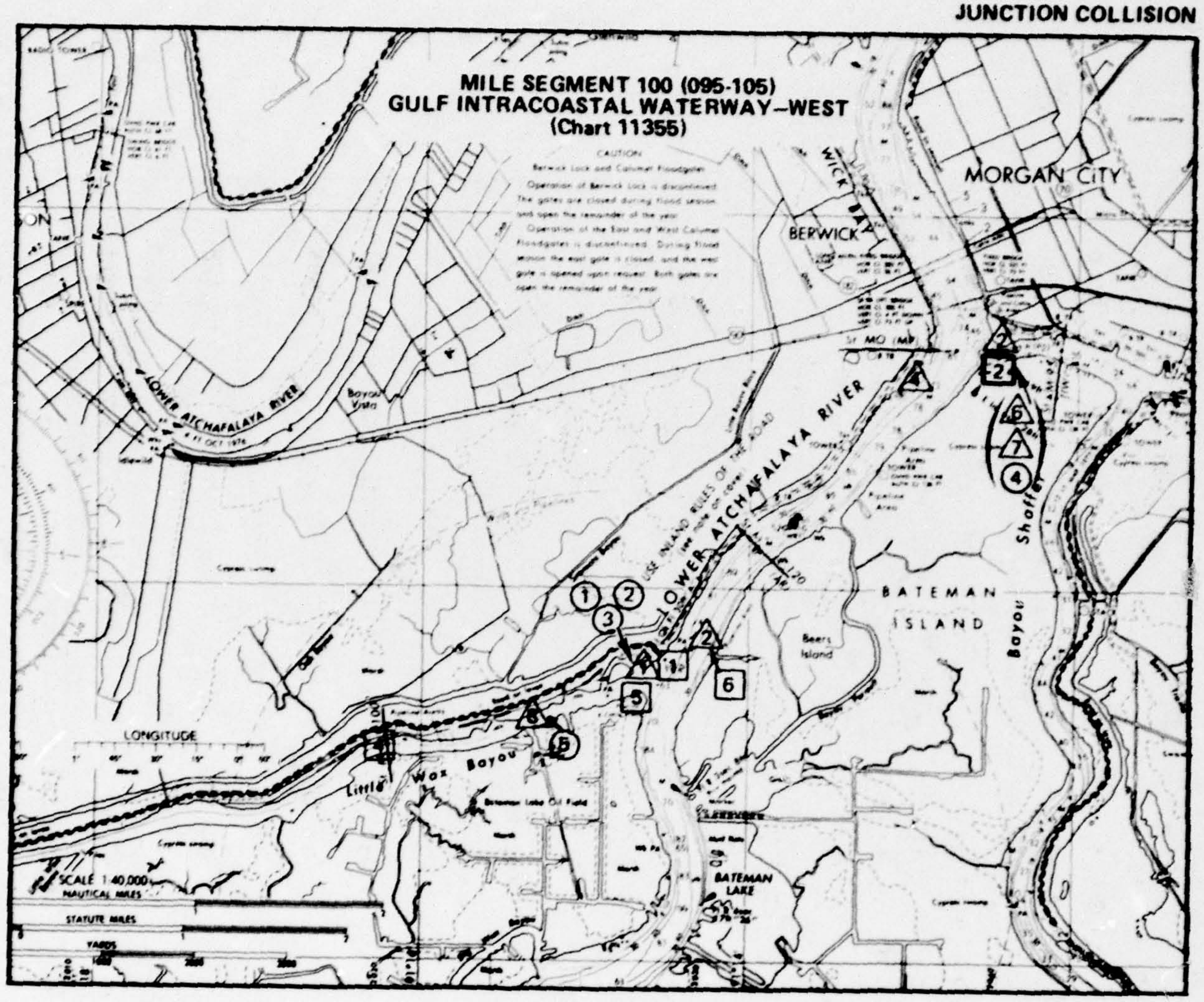


FIGURE 3.13. COLLISION SCENARIO
(Note collision number "2": $\boxed{2}$)

The vessels are attempting to pass each other in a narrow canal or in an area restricted by moored barges. The pilots have communicated and a port-to-port passing agreement is reached. In preparation for passing, one vessel is guided to the right side of the channel. The other pilot judging this to be enough room for safe passage or expecting the other vessel to move even further over, continues his approach with little or no modification of his original course. As the vessels get closer, it becomes apparent that there is not enough room to pass safely; last minute efforts are ineffective in preventing accident. Figure 3.14 illustrates this situation.

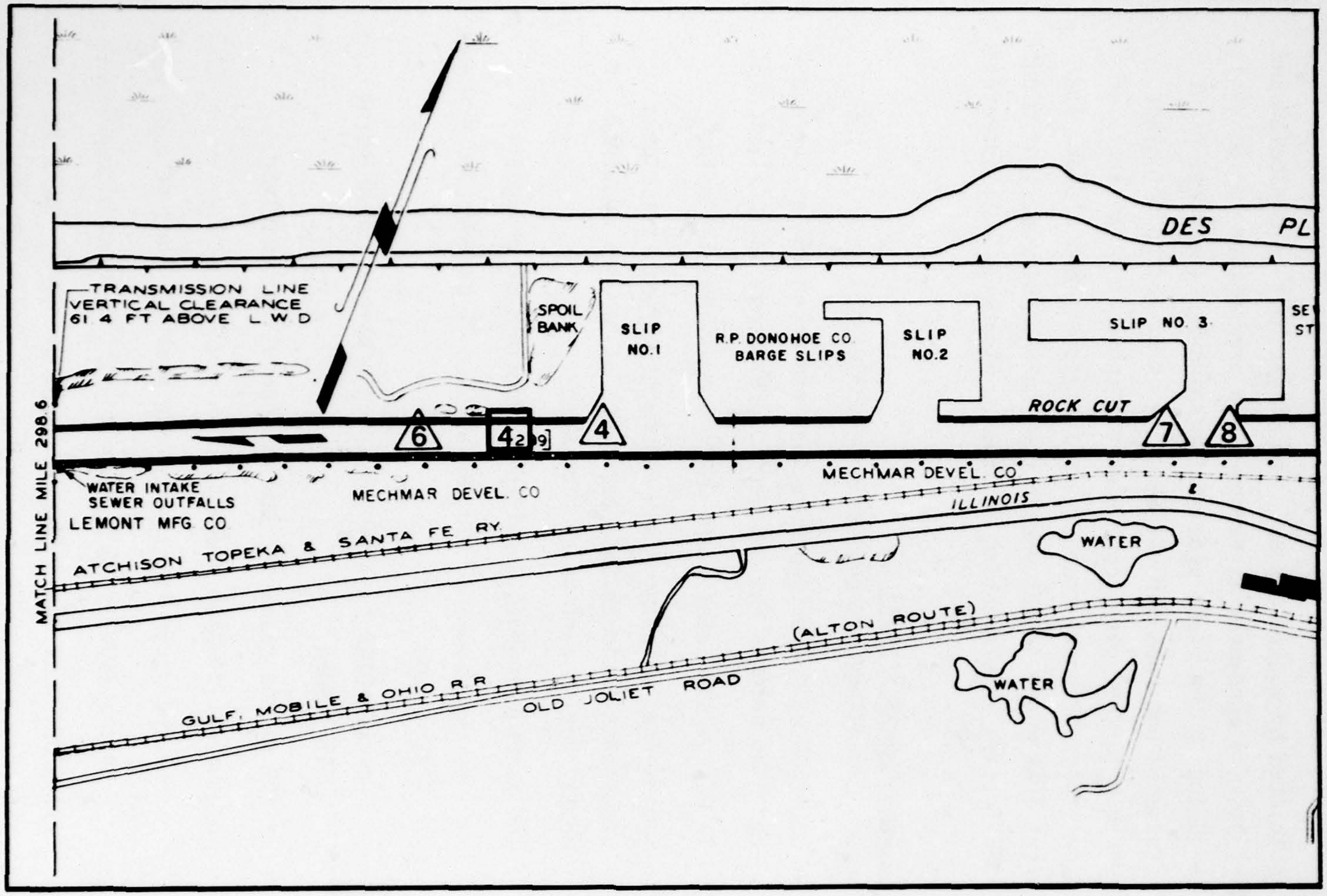
Tendencies in Rammings at Bridges

(Averages include groundings and collisions at bridges.)

- Rammings of the bridge structure represent 75% of the accidents at bridges (as opposed to groundings and collisions).
- In 80% of the cases there was a bend within 1/2 mile.
- Time series relating river discharge curves to accident occurrence indicate that accidents at bridges occurred mostly during periods of high water.
- The average towboat involved in rammings at bridges:
  - on the rivers is 3300 HP pushing 10 barges (330 HP/barge) 79% loaded
  - on the GIWW is 1144HP pushing 3 barges (381HP/barge) 54% loaded.
- In 79% of the cases the tow was operating downriver.
- The typical towboat operator:
  - on the river is 43 years old with 17 years of experience
  - on the GIWW is 40 years old with 13 years of experience
- Fifty-four % of the accidents happened during hours of darkness.

CORPS OF ENGINEERS

CANAL COLLISION



COLLISION □
RAMMING △
GROUNDING ○

FIGURE 3.14. COLLISION SCENARIO
(Note collision number "4" : $\boxed{4}$)

- Interviews with pilots indicate that bridge passages are complicated by:
  - bridge location
  - high water
  - wind on empties
  - cross currents.

Ramming Scenario - Bridge

The tow is proceeding downstream, pushing nine loaded barges. The pilot is 40 years old and has 13 years of experience. He knows the waterway characteristics thoroughly, and has made this run many times before without incident.

The river stage is high and as the pilot negotiates a bend above the bridge he is not immediately aware that the tow is sliding toward the center of the river. As he corrects and pushes back toward the left descending shore, the faster current in the center catches his stern and rotates the tow. Frantic maneuvering to line up for the bridge causes a towing cable to snap and the barges begin to separate.

\- OR -

Being out of shape just above the bridge, the pilot tries to maneuver to realign for the bridge space but lacks sufficient distance either to stop in time or to flank back into position and hits the bridge pier.

\- OR -

It is dark and the area has few shore lights. The bend shields those that are present. When the bridge come into visual range, the piers are difficult to detect, making it difficult to realign, and the tow hits the bridge. Figure 3.15 illustrates this situation.

BRIDGE RAMMING

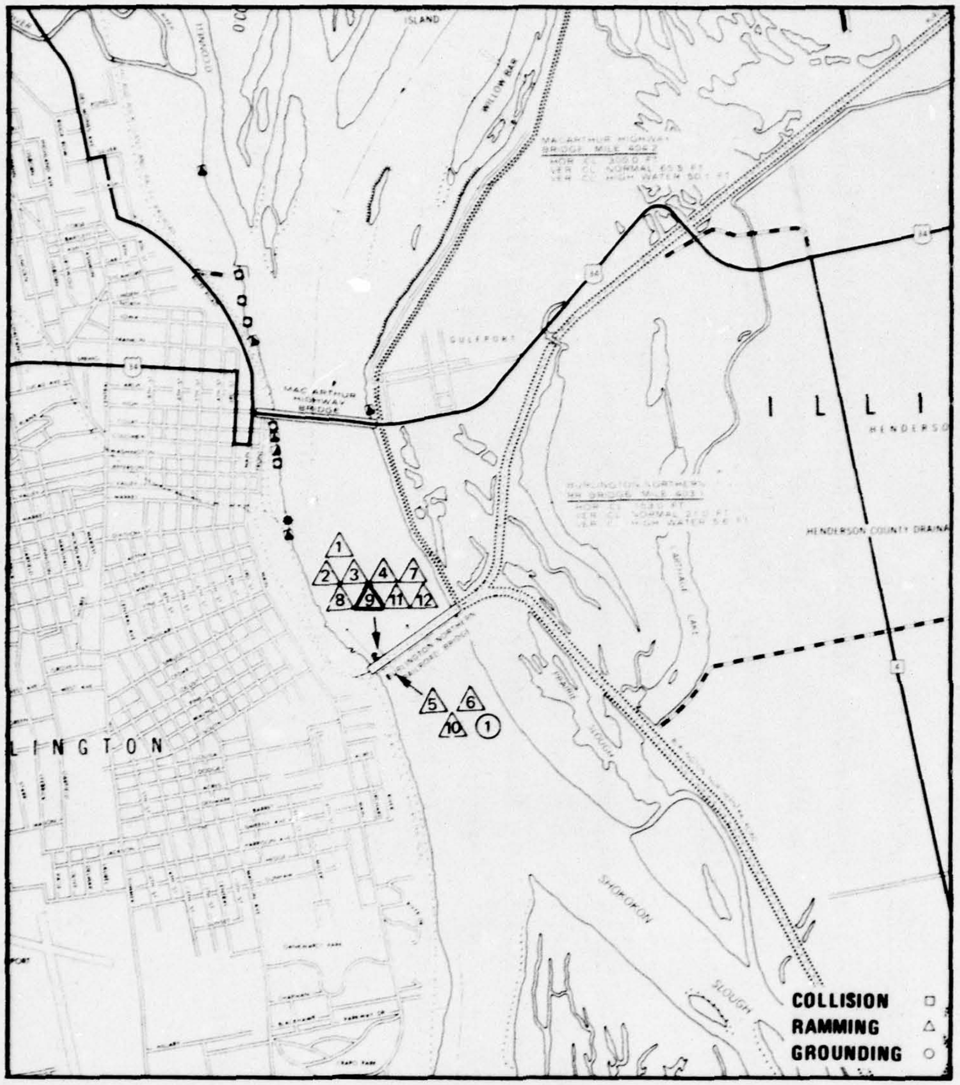


FIGURE 3.15. RAMMING SCENARIO (Bridge)
(Note ramming number "9" : 9)

Tendencies in Rammings at Locks

(Averages include groundings and collisions at locks.)

- Ramming of the lock structure is the basic accident mode representing 84% of all accidents of locks studied.
- In 44% of the cases there was a bend within 1/2 mile.
- In 50% of the cases the tow was operating downriver.
- The typical towboat:
  - on rivers is 2951 HP pushing 8 barges (368 HP/barge) 85% loaded
  - on the GIWW is 1392HP pushing 3 barges (464 HP/barge) 65% light.
- Forty-nine % of all accidents happened during hours of darkness.
- River discharge curves indicate that accidents occur during all river stanges.
- Interviews with pilots indicate that lock passages are complicated by:
  - lock orientation
  - high water
  - eddy below dam
  - cross currents above dam.

Ramming Scenarios - Lock

Lock Upstream. The tow is proceeding downstream approaching a lock. The river stage is high. There are cross currents above the lock caused by the shape of the shore and the dead water in front of the lock. The tow hugs the bank and slowly approaches the lock. As the head reaches the dead water at the lock entrance, the stern catches the cross current and is set out toward the center of the river. The tow rotates on the lock wall and drifts down on the dam. Figure 3.16 illustrates this situation.

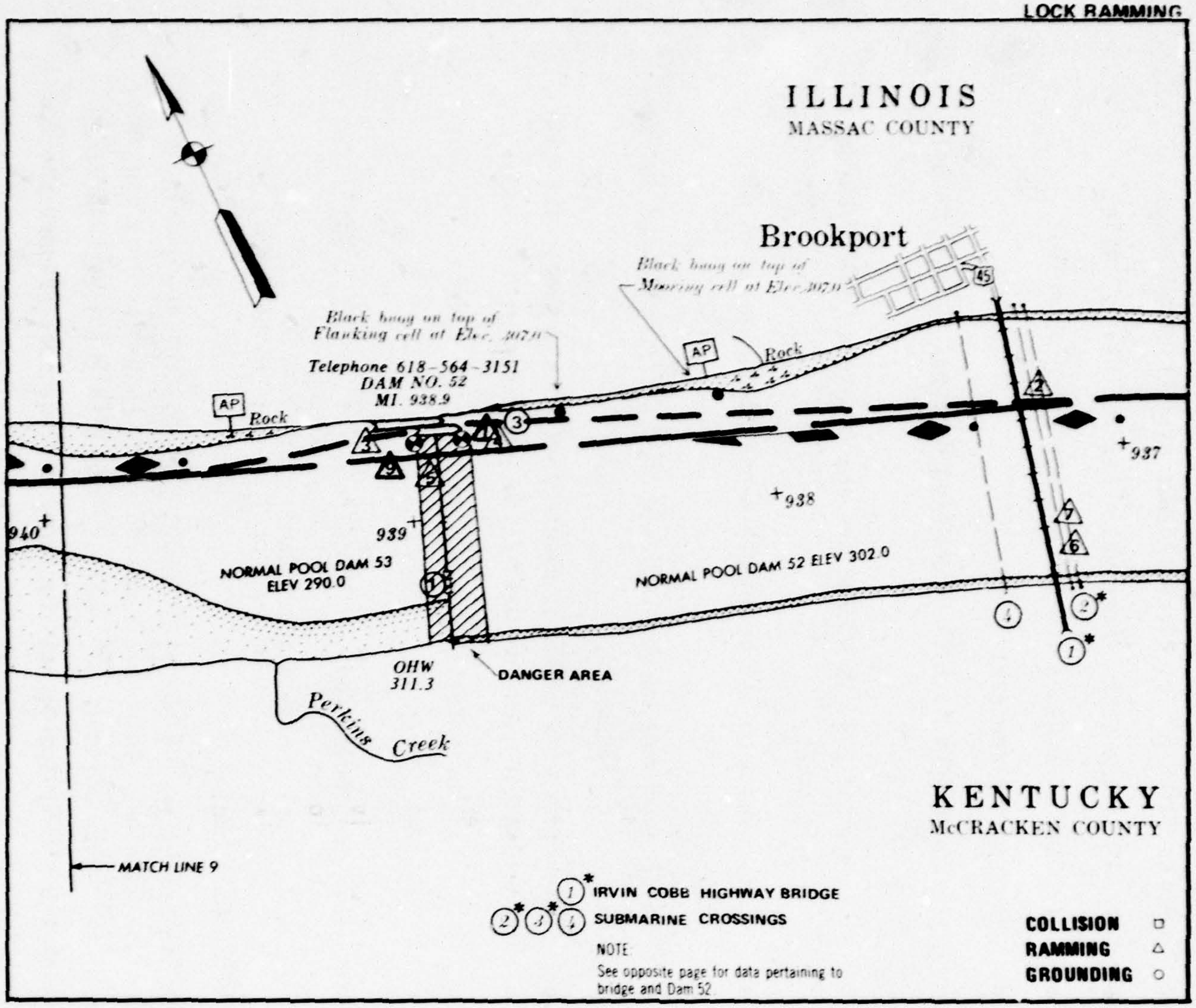


FIGURE 3.16. RAMMING SCENARIO (lock)
(Note ramming number "9" : △, downstream;
ramming number "1" : △, upstream)

Lock Upstream. The tow is proceeding upstream. The river is high and the bear traps on the opposite shore create a strong eddy extending hundreds of feet below the dam. As the head of the tow reaches the eddy, the head is set to starboard. The pilot compensates and pushes ahead. As the head reaches the lock entrance the eddy sets the head to port and pushes the stern to starboard. The pilot again compensates to maintain his alignment and to enter the lock. The cross currents are too strong and the tow hits the guide wall.

- OR -

The tow is slightly misaligned and strikes the lock wall.

- OR -

The eddy catches the stern as the tow enters the lock and accelerates it into the lock.

- OR -

The pilot misjudges his speed and strikes the lock gate. Figure 3.16 illustrates this situation.

Tendencies in Grounding Characteristics

- The typical towboat operator is 39 years old with 11 years of experience.
- The typical towboat:
  - on rivers is 3509 HP pushing 7 barges (501 HP/barge), all loaded.
  - on GIWW is 1856 HP pushing 3 barges (619HP/barge), all loaded.
- In 74% of the cases, the tow was operating downriver.
- In 81% of the cases there was a bend within 1/2 mile.
- Forty-six % of accidents happened during hours of darkness.
- River discharge curves and causal factors data indicate that groundings are primarily attributable to getting out of shape in moderate and high water.

Grounding Scenario

The tow is operating downstream pushing six loaded barges. The river is high and the operator hugs the left descending shore as he approaches a left-hand bend. Rounding the bend he does not compensate the slide in time and is swept out toward the center of the river. The faster current at the center catches the stern and rotates the tow broadside to the current. The tow grounds on the right descending bank. Figure 3.17 illustrates this situation.

ACCIDENT CONSEQUENCES AS INDICATED BY DAMAGE COSTS

Damage costs are one indicator which may be used to judge the severity of safety problems. Figure 3.18 - 3.22 show the costs of vessel, cargo and other property damage from towboat and barge accidents each year, FY 1972 through FY 1976. The data in these figures were taken from a computer listing generated by the Coast Guard's Automated Vessel Casualty File. The source of the input to that system was the form CG-2692, on which damage estimates provided by the master, owner, or operator of the vessel are recorded. Figures 3.18 - 3.22 represent the total population of collisions, rammings and groundings involving a tug/towboat and/or barges that were reported during the study period.

Estimated Costs by Type of Damage and Year

The cost distributions are shown to be quite similar year to year. In general, vessel damage seems to be the primary accident consequence measured by cost. Damage to cargo was comparatively trivial in these accidents. Damage to other property, mostly to bridges and locks, was in between. Very few fatalities and serious injuries resulted from these cases.

The distribution for all three types of damage tends to be bimodal. That is, two cost trends are seen, with a substantial portion of the cases in the lower categories, from $2,000 to $10,000, and another substantial portion in the category of $30,000 or more. (A bimodal distribution is one that has two statistical modes. The statistical mode is the most frequent value of a set of data.) It should be noted that the two peaks in the cost histograms might be an artifact of the way the cost categories were defined. The cutoff at $30,000 may

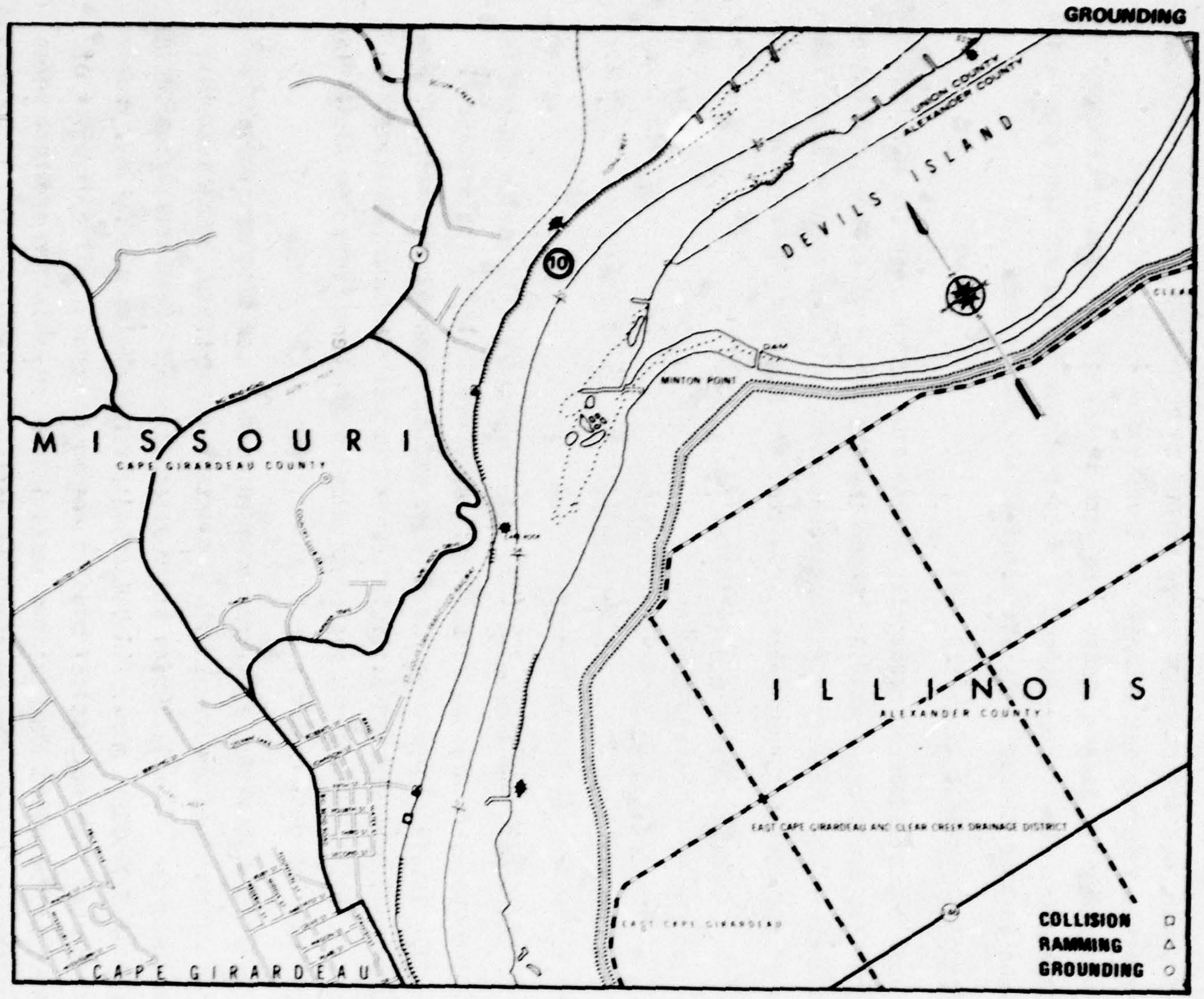


FIGURE 3.17. GROUNDING SCENARIO
(Note grounding number "10" : 10)

be too low. If the range continued to be extended in equal intervals, the second peak might disappear.

When there is vessel damage it is more often to a barge or barges than to the towboat, but the costs of barge damage on an individual basis are typically relatively low. The peaks at the lower end of the cost scale represents primarily barge damage. The peak in the $30,000-and-up category represents primarily towboat damage. Sixty towboats in the accident population were found to have damage costs estimated at $30,000 or more.

Verification of Estimates

A list of those 60 cases was sent to five marine insurers who indicated willingness to provide information concerning the amount of claims paid against each of those cases. These five companies collectively represent a significant portion of the towboat underwriting industry, which is a diverse group:

- American Marine Underwriters, Inc.
- Neare Gibbs and Company
- United States Salvage Association
- The Travelers Insurance Company
- Marine Office of America.

Altogether, the companies were able to provide information on one of five of the cases, or 20%. It should also be noted that, on the average a claim file is open for approximately five years. Accordingly, most of the cases are still open and still subject to additional claims or finalization of existing claims. In addition, when litigation is ongoing, often no claim information is available.

Table 3.18 gives, by case number, the amount of monetary damage indicated on the form CG-2692, the actual insurance costs to date, and a comparison between the two. The CG-2692 estimates range from 97% lower than actual costs to date to 92% higher. Nevertheless, combining all cases, the CG-2692 underestimated the total actual costs to date by only about 15%. Overall, the data presented in Table 3.18 suggest that the Coast Guard estimates are generally correct from an "order of magnitude" viewpoint.

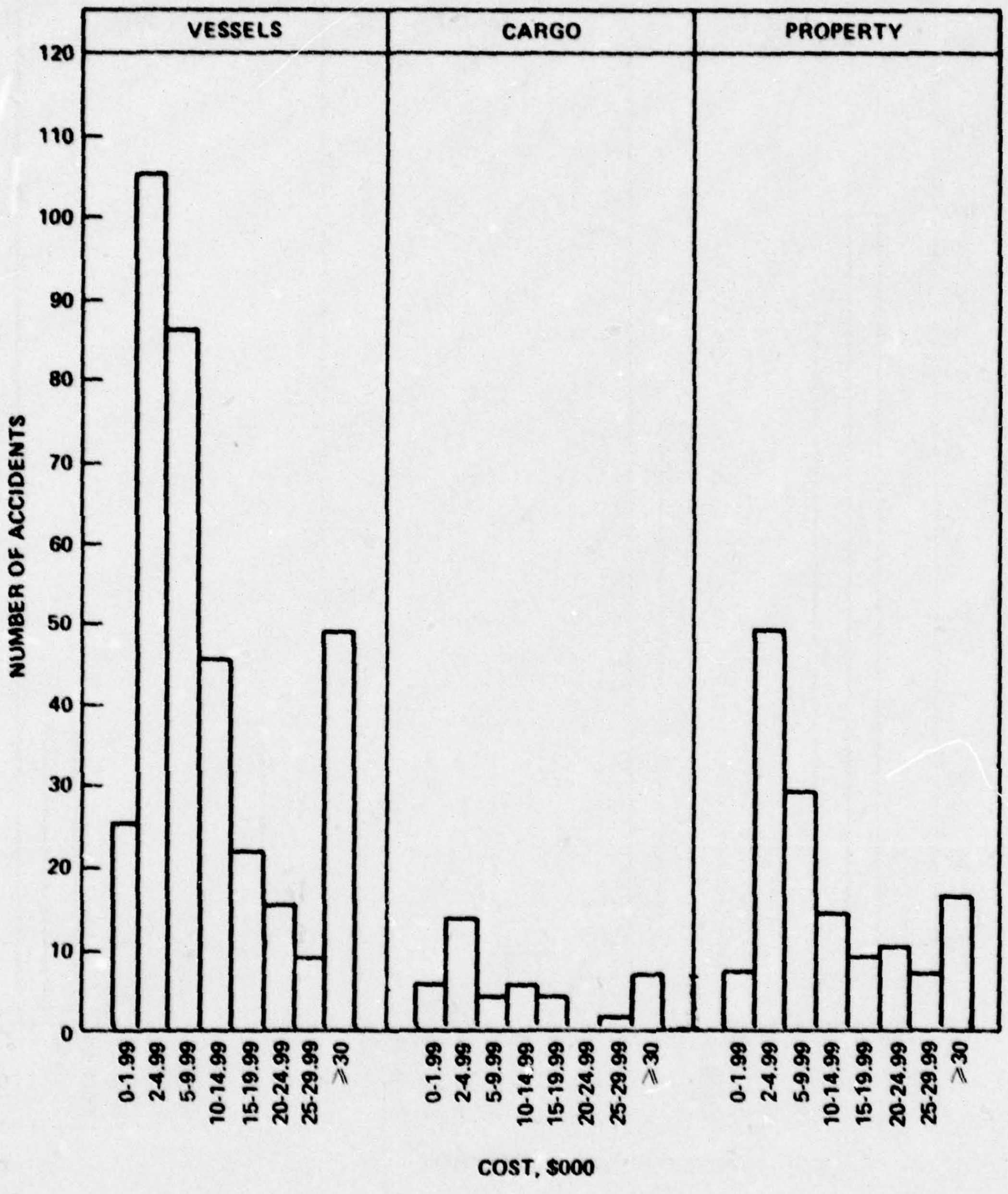


FIGURE 3.18. NUMBER OF CASUALTIES/COST INTERVAL FOR VESSELS, CARGO, PROPERTY--FY 1972

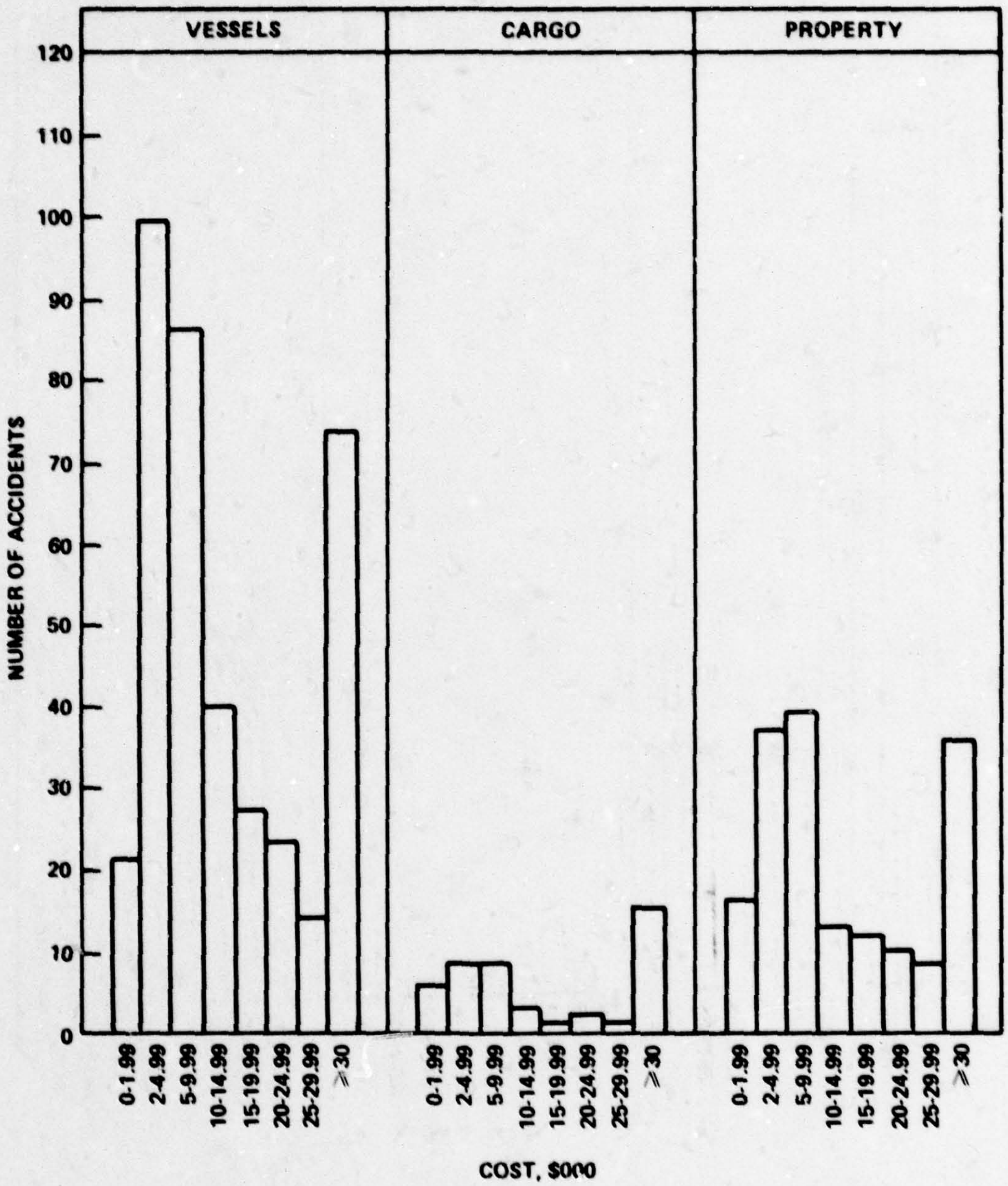


FIGURE 3.19. NUMBER OF CASUALTIES/COST INTERVAL FOR VESSELS, CARGO, PROPERTY--FY 1973

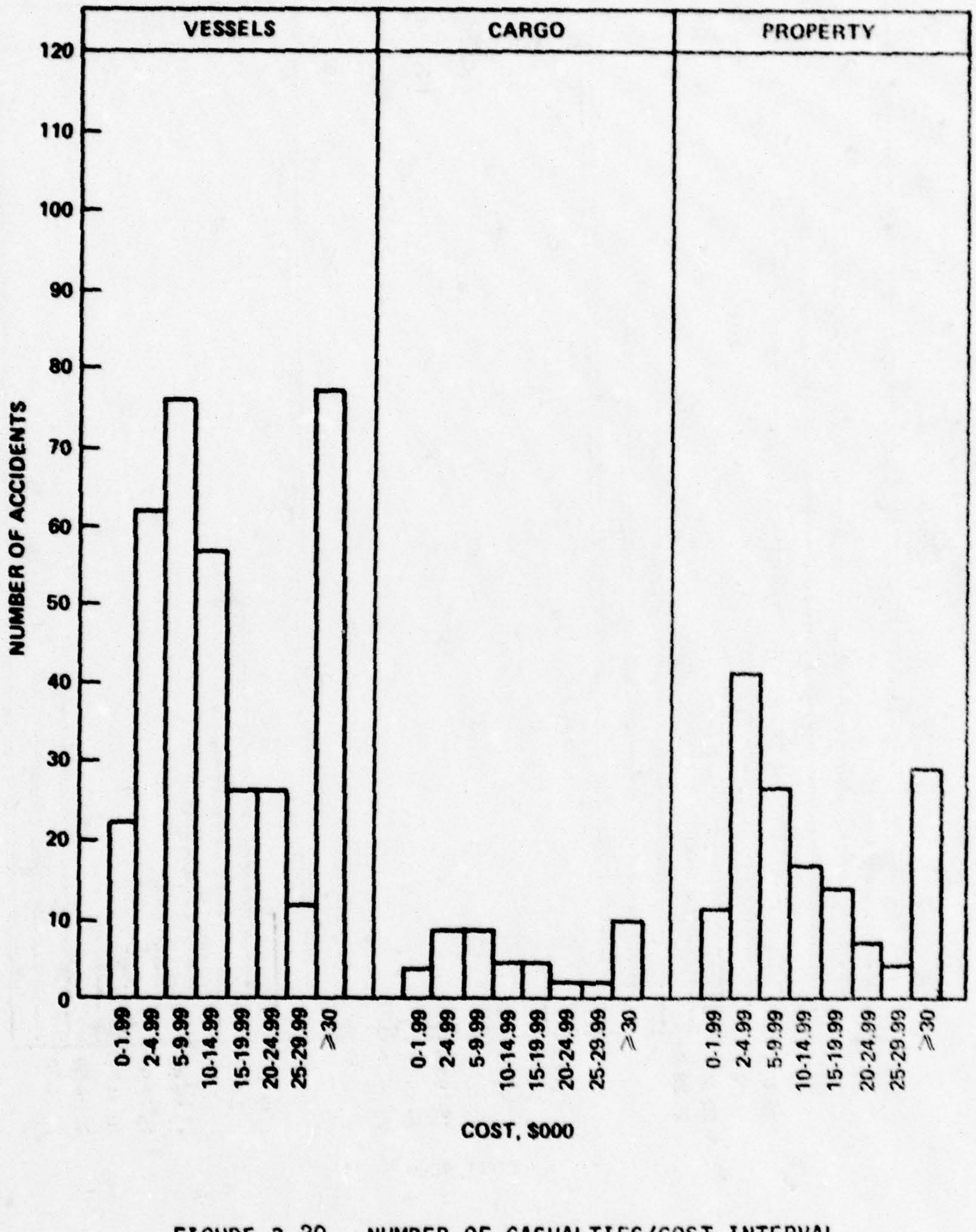


FIGURE 3.20. NUMBER OF CASUALTIES/COST INTERVAL FOR VESSELS, CARGO, PROPERTY--FY 1974

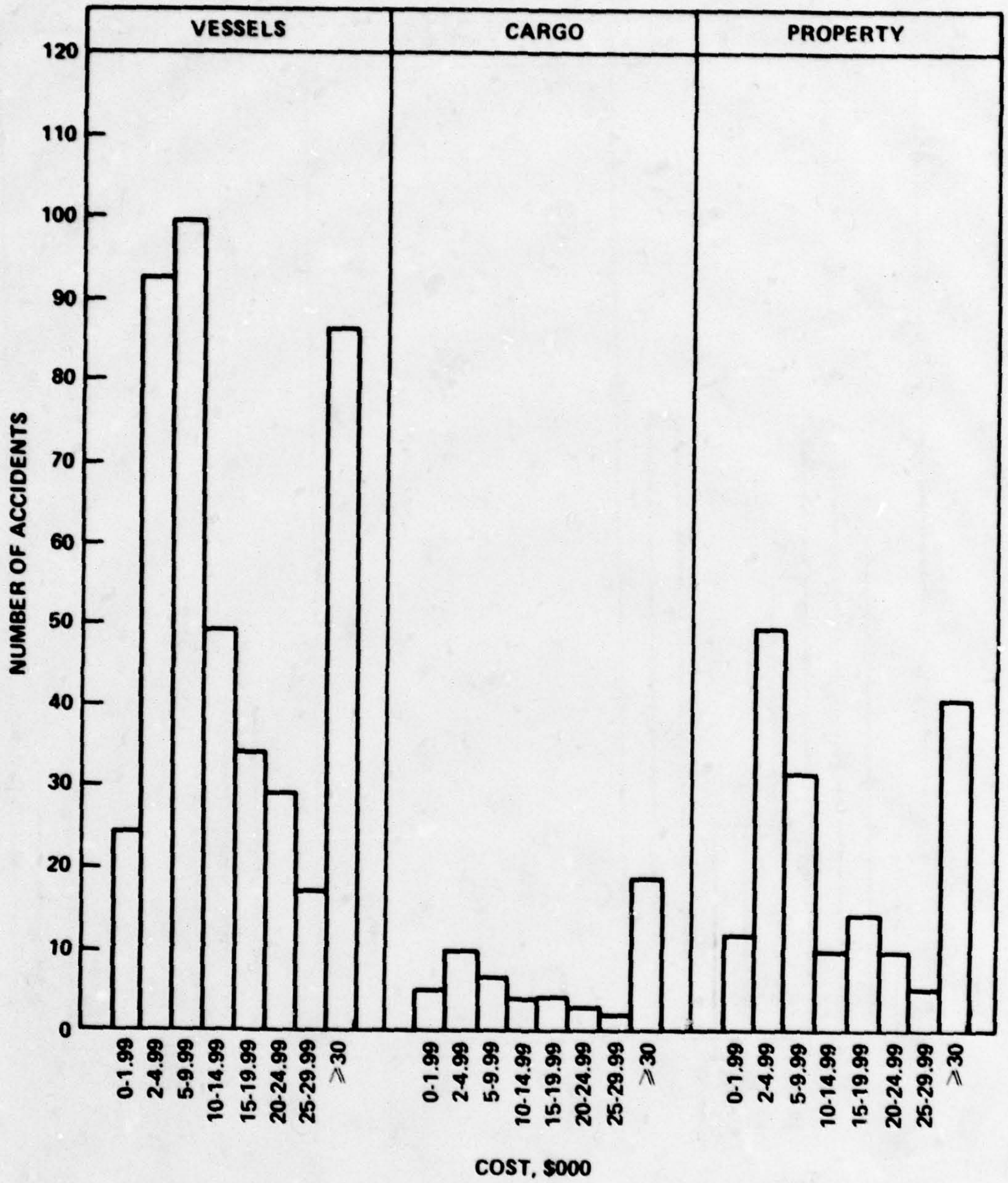


FIGURE 3.21. NUMBER OF CASUALTIES/COST INTERVAL FOR VESSELS, CARGO, PROPERTY--FY 1975

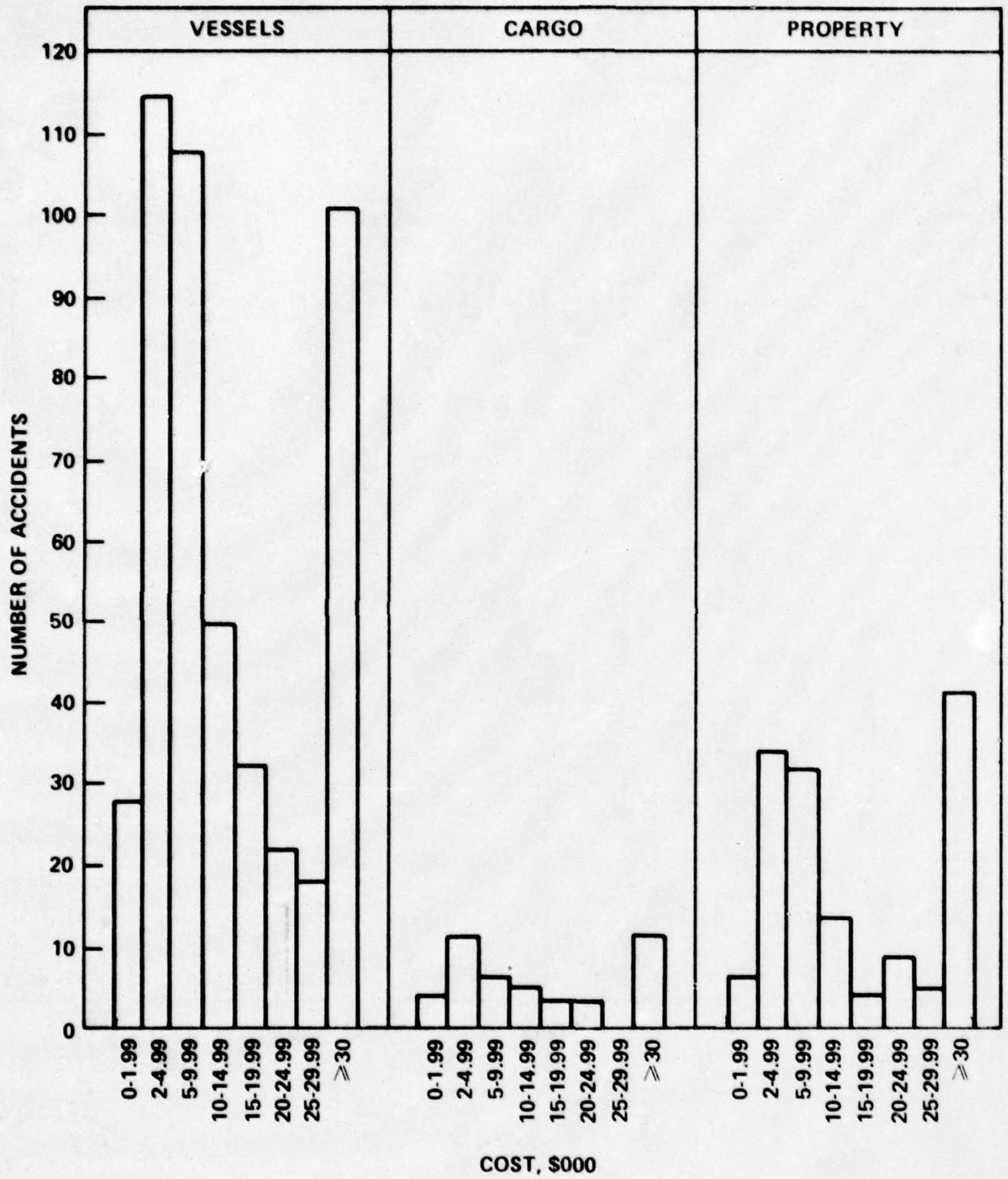


FIGURE 3.22. NUMBER OF CASUALTIES/COST INTERVAL
FOR VESSELS, CARGO, PROPERTY--FY 1976

TABLE 3.18

COMPARISON OF CG-2692 ENTRY FOR MONETARY DAMAGES VERSUS ACTUAL INSURANCE COSTS a/

Case Number	CG-2692 Entry	Actual Insurance Costs to Date b/	CG-2692 Entry Relative To Actual Insurance Costs
20475	$ 30,000.00	$ 21,328.22	1.407
22281	$ 30,000.00	$ 27,531.97	1.090
40310	$ 20,000.00	$ 11.004.00	1.818
52665	$ 5,000.00	$ 153,245.00	0.033
21355	$ 250,000.00	$ 130,000.00 c/	1.923
21068	$ 1,000.00	$ 1,247.00	0.802
22381	$ 30,000.00	$ 55,000.00	0.545
42714	$ 50,000.00	$ 78,335.00	0.638
43046	$ 45,000.00	$ 26,384.00	1.706
52458	$ 13,000.00	$ 77,107.00	0.169
32316	$ 750.00	$ 500.00	1.500
52823	$ 136,000.00	$ 139,536.00	0.975
TOTAL	$ 610,750.00	$ 721,218.19	0.847

a/ From 60 case files within applicable data base which had monetary damage to towboat indicated for which insurance company sources had information.

b/ Sources: American Marine Underwriters, Inc., Neare Gibbs and Company, U.S. Salvage Association, Travelers Insurance Co., and Marine Office of America.

c/ Total insured value was $130,000.00.

IV. CONCLUSIONS AND RECOMMENDATIONS

The study conclusions are divided into two parts. The first part is concerned with problems. It is a discussion of the nature and, especially, the interdependence of the human and physical factors that were judged to be most important in limiting the reliability of towboat-barge control. The second part has to do with possible solutions. It is a discussion of ways of altering the system to increase the reliability of control.

As a context for the conclusions, some commentary on human factors engineering and human factors analysis may be helpful.

HUMAN ENGINEERING, HUMAN FACTORS, AND HUMAN ERROR

Human engineering, narrowly defined, is the science of equipment design for efficient use by people. This segment of human engineering deals with such problems as optimal arrangements of equipment, lighting, placement of controls, resistance of a control lever or dial, etc. In a broader sense, human engineering is an aspiring science of the management of human performance by optimizing the system of which it is a part, in light of human characteristics and capabilities.[1] This study fits within the broader

[1]The system includes everything that is brought to bear to accomplish some set of goals and objectives in an organized manner. In the present case, the system includes the waterways; towboat operating companies and their policies and procedures; laws and regulations; regulatory agencies and their policies and programs - among other elements - in addition to vessels, their equipment and personnel.

definition of human factors analysis and engineering. Under the broader definition, human factors - the subject matter - can also be viewed in at least two ways. The pertinent definition of "factor" in the dictionary (Webster's New Collegiate, eight edition, 1977) is "anything that actively contributes to the production of a result." Human factors, then, may be defined as characteristics (capabilities, beliefs, attitudes, actions, inactions, etc.) of people which influence the system performance for better or worse. Human factors may also be seen as characteristics of the system which impinge on human performance, for better or worse, given human characteristics. Either way, human factors analysis and engineering seek to understand and allow for, compensate for, change, control, or take maximum advantage of human characteristics by adjusting system design to achieve the most efficient and effective performance possible from both man and machine.

"Human error" is a term that seems to be interchanged freely with "human factors," but it is important to keep in mind that the two are not synonymous, although they are closely related.

Human error as used in discussions of marine safety often connotes some sort of shortcoming or failure. For example, ship operators are typically said to "not recognize some environmental disturbance such as current" or "misjudge the effect of a current" or "not properly align the vessel within the channel" when an accident occurs. Another typical example is the operator "failed to sound the proper whistle signal in violation of the Rules of the Road." The implication is that the operator ought not to have made such a mistake and that if he had not, the undesired event would not have occurred. Although this position might be defensible in some cases, it oversimplifies the problem. First, it assumes that only one factor "causes" the accident. Second, it assumes that the "environmental disturbance" (or any other information bit) can be perceived with precision, in time for action; that to perceive it is to know what to do about it; and that the disturbance can in fact be compensated for by both the human operator and his vehicle. A third assumption is also implied, and this one seems to be the fundamental one. The human error explanation of accidents generally gives the impression that the system is otherwise perfect: The information

is readily available; its implications are clear; the vessel can respond; the operating area is suitably designed; the Rules of the Road, if followed, assure safety.

Given the foregoing notion of human error and the assumptions it implies, it is easy to understand why the vast majority of accidents are said to emanate from human error. With this definition of human error, anything short of outright mechanical failure within the system or an Act of God is a human error. In fact, one could also argue that even the outright mechanical failures are human error in design, maintenance, or whatever.

Human error may perhaps be defined more realistically and productively as some human action or inaction, regardless of fault or blame, which ultimately contributes to an undesired event. This definition makes human error a subset of the first definition of human factors given above. To make distinctions, "human error" might be used to refer to what the operator did, did not do, or could not do, regardless of fault or blame, while "human factors" is used to refer to the factors that contributed to the operator's behavior. The latter term takes in both human attributes and other system attributes.

Looking at human errors in this way, they continue to be seen as active in most accidents; but often they are seen as indicators of underlying human factors problems. We get away from the tendency to pronounce an operator at fault and close the case. This is important if anything is to be done about accidents beyond talk and litigation.

It is recognized that some human errors stem from incompetence. Mistakes are made. People may be inattentive, careless, reckless, poorly informed, or incapacitated, temporarily or characteristically. The accident reports indicate however, that incompetent errors represent a minor or insignificant portion of all human error in towboat control, and they are not further considered within the scope of this work.

Competent errors are those made by operators who are considered to possess reasonable abilities, those who perform their work successfully day after day and who were not apparently incapacitated at the time of an accident. Within this category, the errors made by the operator can often be attributed to any number of factors, and rarely, if ever, does only one factor appear to cause a competent error. There can be error components introduced by various factors within the situation in which the operators must work, and also error components introduced by the operators' responses. Situation and response are interactive, altering each other and both contributing to the negative outcome.

The typical errors in towboat control appear to be in the competent category. We did not learn as much about them as was desired, because the accident reports generally allude to operator behavior in accidents in terms of results (e.g., failed to keep to the right) if at all. Moreover, most of the tasks of pilotage are thinking and perceiving tasks, which are not well understood and are difficult to describe. However, using the reports with the charts of the accident locations, it was possible to identify the kinds of situations in which competent errors tend to arise. Similarly, by relating the causal factors cited in the reports to vessel control task requirements it was possible to identify the tasks which seem to be most uncertain. From this information it is possible to draw conclusions about salient human and physical factors contributing to unreliability in vessel control and to see possible solutions, even though the processes are not entirely understood.

CONCLUSIONS ABOUT ACCIDENT CAUSES

The most general and basic conclusion of this study is that the accidents examined typically arose from expectable variance in the accuracy and timing of control decisions and actions, in situations in which the safe path had to be defined and adhered to with considerable precision - i.e., in situations in which there was little margin for error.

Two kinds of evidence support this conclusion:

- The clustering of accidents in locations characterized by certain kinds of hazards and maneuvering limitations
- The descriptive information and causal factors cited in the accident reports, which rarely identify conditions or behavior beyond the pale of normal operations.

Clustering of Accidents

As shown in Section I (Table 1.1) five waterways accounted for 86% of all collisions, rammings, and groundings that occurred on the Western Rivers and the GIWW during the study period. Moreover, over those five waterways, providing more than 3000 navigable miles, clusters of accident were seen in 35 10-mile segments against a field of widely dispersed accidents. The accidents in these segments, totaling 350 miles, or on the order of 10% of the navigable distance, comprise 30% of the accident population. Actually the navigable distance encompassed by the high frequency sites is considerably less, since within each 10-mile segment the accidents tend to be highly localized. (See Section I, Tables 1.2 through 1.9 and associated text for more detailed information. See also the first part of Section III.)

The 35 segments where relatively many accidents occurred (at least 10 during the 5-year study period on the rivers and at least 15 on the GIWW) all were found to have one or more (usually a combination) of the following limiting physical characteristics: a bridge, a lock, a bend or intersection, or very narrow channel width. (See Tables 3.1-3.5; also Figures 3.12-3.18.) These are concluded to be major fixed physical factors contributing to the unreliability of vessel control. It seems reasonable

enough to expect that, especially in combinations, these factors would intensify accident potential. The major structures and restrictions, along with variable environmental conditions, primarily currents (also winds, congestion, low water, and others) increase the difficulty of the maneuvering problem and the reduce the likelihood that human errors (as previously defined) in control decisions and actions, as well as normal variance introduced by the equipment, can be tolerated.

Nature of Causal Factors Cited in the Reports

The accident reports overwhelmingly pointed to environmental forces and conditions as the significant causal factors in the cases studied. Collision cases (two moving vessels) were the exception. In those cases, task performance factors were more frequently cited; although environmental components appear to have been involved, they were not necessarily referenced.

Tables 3.16 and 3.17 show that current and wind were explicitly cited in 56% of the rammings and 40% of the groundings. By comparison, they were cited in 17% of the collisions, which occurred mostly on the GIWW-West. Other factors were cited, more oriented to tow/operator performance, that implied current or wind effects, especially the former, or both. These factors include "out of shape in bend," "not properly aligned," and "lost control."

We have read several thousand accident reports in this and related studies of harbor accidents. From this experience it is believed that personnel faults and violations of the Rules are most likely to be put down as "the cause." This tendency seems to stem from the view of human error previously discussed. Also, the Coast Guard has statutory responsibility for assuring that vessel personnel are adequately qualified as well as that vessel and equipment are sound. Thus personnel errors and vessel/equipment failures are of primary concern during accident investigations. The latter are found relatively infrequently and there must be physical evidence. Human error can be inferred in almost any situation. If a Rule of the Road has been violated, this must be reported regardless of its significance in the sequence of events. All this is to say that the language of human error or personnel fault is very likely to be seen in vessel acci-

dent reports. The fact that it is seen in so few of the reports studied, is believed to reflect recognition of the importance of the underlying human factors in these cases.

As noted above, the collisions cases are different in that task performance failures were more frequently cited and environmental forces and other situational factors somewhat less frequently. However, most of the collisions studied occurred on the GIWW, at a bend or intersection (or junction). These characteristics of the channel are believed to have implications similar to those of current effects.

The pilots comments reflect the complexity of the vessel control process in the accident locations studied. A few of their comments are included here to illustrate:

> Just above the bridge the current is relatively steady and parallel with the bank. As the tow gets closer to the bridge, at about mile 44.3, the current divides because of a bend at the bridge. One branch of the current hugs the left descending shore, and one branch crosses the river toward the right descending shore. Tows must approach the bridge on an angle to counteract the set of the current. In addition, they must steer around the bend at the bridge which causes a slide toward the right descending shore and in the direction of the current. Three dikes have been installed above the bridge, and one below, which do not appear on charts. Below the bridge there is a relatively narrow channel lined with rocks on both sides.
>
> Tows have difficulty because of forces of current and wind and shallow water hydrodynamic forces. The towboat has limited instrumentation (radar, turn indicator, and depth finder) to operate in this environment. Instrumentation for displaying speed through the water and speed over the ground would be useful for determining stopping distance.
>
> Lock 52 is a wicket type dam which consists of gates hinged at the bottom of the river. A gate called a "bear trap" is positioned on the side of the river opposite the lock. The bear trap is used to adjust the river level, and a large quantity of water passes through the bear trap. The combination of high current on one side of the river and slack water behind the lock creates the eddy and an updraft or water running toward the lock. The exact location of the eddy varies with river stage and how the lock master regulates the flow over the dam and through the bear trap.

Each lock has its own characteristics. The worst lock is the Gallopolis Lock. It carries the most tonnage on the river. It is a high-lift dam and is so congested that tows must wait sometimes 2 days to lock through. There are cross currents on the upstream side and eddies below. It is more difficult to get into the upstream side of this lock.

Approaching the Gallopolis from upriver is also a problem since the lock is constructed at an angle to normal current flow. As the tow approaches from upstream, it cannot line up with the lock or the current will catch the stern and sweep it out into the river. The pilot must flank into position and hold the stern next to the bank until the head of the tow is near the lock entrance. Then he ties off the stern and steers the head around into the lock.

At Lemont, mile 300.5, the wind is a big problem. The Lemont Highway Bridge is narrow, and barges are tied up on both sides of the canal. A towboat must have a retractable pilot house to pass under bridge, and vision is restricted. It is delicate work passing between strings of moored barges, and collisions ofter occur.

Major Physical Factors in Accidents

Overall, the accident potential appears to be greater where there is a structure of restriction to be negotiated. . .

- on a downriver passage
- when there is a bend either above or below
- when there are cross currents and/or cross winds
- during higher water periods, in particular, for passages through bridges.

In addition, there is some indication that accidents at bridges tend to occur somewhat more frequently at night.

Among the towboat and array characteristics, array dimensions in relation to the physical boundaries encountered seem to be the most significant indicator. Loading also seems to be a factor, with most accidents involving loaded barges except on the GIWW. However, since trips with empties are not so profitable, they are avoided. The extent to which fewer numbers of such trips account for the predominance of loaded barges in the cases studied is not known.

The tows in the accident cases were not very large. The big towboats with horsepower sufficient to handle the very large tows (e.g. 10,000 HP or more with an array of up to 40 barges) did not come on the line until 1975-76. However, the data on tow breadth versus bridge span and lock width suggest that tow dimensions are close to the limit imposed by the major structures along with three of the waterways studied, the Lower Mississippi excepted. Larger tows would have to be broken down and taken through in sections. It was shown (Table 3.11) for three of the five waterways, the ratio of bridge span to tow breadth in accidents at bridges ranged from 1.7 to 2.6. Alignment in such circumstances is critical, and when the bridge is approached coming out of a bend, the job of lining up and holding alignment can be very difficult. It may not be possible to see the bridge far enough in advance; the impact of current already has been discussed. Add an encounter with another vessel or an obstacle along the side (such as a moored or grounded vessel or dikes), and maintenance of alignment becomes more problematical.

The ratio of lock width to tow breadth is typically even lower of course, averaging from 1.1 to 1.5. Although locks are less likely than bridges to be found at bends, there are other problems. As noted by one of the pilots interviewed, Gallopolis lock is constructed at an angle to the normal current flow. Another pilot noted the bridge built close on to the entrance to Calcasieu Lock. Even when such special complications do not exist, congestion is very likely, with tows waiting to lock through.

The angle of a bend in relation to tow length and breadth may be another significant factor in all three types of accidents studied. Current and wind direction and speed and tow loading are pertinent to the implications of this relationship for control. Analytical modeling is needed to clarify what may be expected to happen given various combinations of channel width and contours, tow characteristics, and environmental forces. Such analyses was not part of this study; we can only report that just under 70% of the cases occurred in, or in close proximity to, a bend (Table 3.2).

Finally, channel width in relation to tow width may be a critical factor, even on a straightaway, as in the canals of the Illinois Waterway and on the GIWW. One of the pilots' comments gives an example of what may be encountered. This situation is on the Illinois Waterway:

> Mile 293.1, Butterfly Dam, is in the middle of the Chicago Sanitary and Ship Canal. The canal is lined with rock walls and barges tied off on both sides. The canal width is 150 feet, and tows must pass through at dead slow speed to avoid moored barges.

The foregoing conclusions about major physical factors are discussed below in relation to each accident type.

Rammings. The most prevalent kind of accident on the waterways is collision with a structure (one type of ramming). Among the structures, bridges are the most commonly hit. Reportable lock collisions are frequent, but less so than bridge collisions. The margin for error in transiting a narrow bridge span or lock, given tow array lengths and widths, may be so small that a minor change in heading can result in contact. Figure 3.23 illustrates. Under these circumstances a moderate cross current or cross wind can result in contact. It is not believed, realistically, that this degree of control can be achieved consistently, given today's instrumentation and control system technology and the external aids available to the pilot. The frequency of bridge accidents tends to increase during high water. Some 60% of all bridge locations in the accident sample have a bend in close proximity to compound the alignment problem.

At night or in poor visibility it may be more difficult to line up, because the bridge piers are difficult to sight. More accidents might thus be expected to occur in darkness and during periods of poor visibility. There are tendencies in these directions, but not of great magnitude. It appears that the day/night difference is not so important, given the difficulty of the control task. With regard to visibility, it is possible that pilots wait until visibility improves before attempting difficult passages.

There are numerous lock contacts without significant damage because the vessels typically are moving at such slow speeds. In addition, locks are more strategically located with respect to river traffic than bridges; they tend to be located in straight, isolated portions of waterways, are well lighted, and are more discernible on radar than bridge piers.

Current was the predominant factor in collisions with both bridges and locks. Visibility appears to be a factor in collisions with moored vessels. The other primary factor seems to be congestion.

Groundings

Most of the groundings in the accident sample also appear to have involved control problems, especially in relation to bends. The ratio of tow length to channel width averaged 1.25, which appears to be significant considering that about 80% of the groundings took place within 1/2 mile of a bend. Current was cited as a factor in about a third of the groundings. Other relatively prominent factors include navigation too close to shore, suction effects, and channel width, plus other vessels or obstacles to be avoided and submerged/uncharted hazards, silting and the like.

The accident sample took in only 19% of the total groundings; they were in general dispersed over the inland waterway system.

Collisions

On the whole, collisions were not so clearly control-related, although a common scenario involved "failure to keep the right" and suction effects in a narrow channel. This suggests insufficient precision in evaluating the maneuvering area and the heading and speed adjustments required for a safe passage; or imperfect timing and precision in the enactment of control adjustments, attributable to man, machine or both. Current effects were typically cited in collisions at intersections or junctions.

Communications and detection problems appear to be more frequent problem areas, width non-use of bridge-to-bridge radiotelephone the most frequent kind of communications failure cited. The accident reports show that radio equipment was either not on or not working properly on 31% of the vessels involved in the collisions, although failure to communicate was recorded as a causal factor in only 14% of the cases. (In many cases, both of the vessels in the accident were towboat-barge configurations, both were judged to have responsibility for the accident and both were included in the data set for analysis.)

Seventy-four percent of the collisions occurred with 1/2 mile of a bend, which may create a blind situation necessitating a broadcast "security call" and response to check for the presence of another vessel. Thus late detection and communications problems overlap.

Human Errors

The accident reports did not, as a rule, provide enough description of the events leading up to the accident to allow the human errors involved to be identified precisely. The possibilities were suggested earlier in this section, in material on the relationships between the causal factors cited in the accident reports and human performance requirements as specified in the Vessel Control Task Analysis (previously referenced).

The findings from the present study are consistent with findings from a recent analysis of accidents in harbor areas.[2] In the harbor study, reports were screened for quantity of information; only those with substantial descriptive material to augment the forms were included. Thus it was possible to be more specific about the nature of the human errors. This more detailed information has been used to support interpretation of the causal information contained in the inland waters accident reports.

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[2] ORI, Inc., Study of Task Performance Problems in Reports of Collisions, Rammings, and Groundings in Harbors and Entrances. Draft final report submitted to the U.S. Coast Guard in November 1978.

Collisions. Human errors appear to have occurred most frequently in the following tasks areas:

- Monitoring and communication via voice radio (Task II. B.11)[3]

- Detection of the other vessel especially at a bend or intersection, also under conditions of poor visibility (Task II. B.11)

- Maintenance of position against current and wind effects, stemming from problems in detection, identification or estimation of the forces (Tasks II. B.2, II. B.6), from evaluation of the control responses required (II. B. 13) or both

- Assessment of traffic and navigational situation, to determine the collision threat (Task II. B.12) and suitable control action (Task II. B.13).

Rammings. The most frequent task problem areas in the ramming cases were as follows:

- Maintenance of position against current effects (and, less often, wind effects), stemming from problems in detection, identification or estimation of the forces in advance (Tasks II. B.2, II. B.6), from evaluation of the control responses required (II. B.13) or both.

- Determination of available navigation distances, relating structural elements and other obstacles to vessel length and breadth and to vessel position and orientation (Tasks II. B.4 and 5, II. B.9 and 10, II. B.12). Problems in precisely determining navigational position and orientation relative to the centerline of the channel (Tasks II. B.4 and 5) may also have been involved in a substantial number of cases.

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[3] Reference to tasks delineated in the Vessel Control Task Analysis and illustrated in flow in Figure 3.11.

Groundings. The major task problem areas in groundings appear to have been like those in rammings, except that problems in the determination of available navigational distances did not involve major structures in most cases. Other vessels or obstacles to be avoided did figure in such problems farily often. The major source problem leading to failure to maintain position where current, wind, and obstacles to navigation were not involved, seems to have been in precisely determining position relative to the channel centerline and limits. Problems in detection of submerged hazards including silting, also were reported, but much less frequently.

Human Factors

Many industry representatives are convinced that the pilots who have accidents are less skillful at their trade than those who do not. The information concerning accident cases and pilot age/experience that is provided in the accident reports does not, in general, support the premise of skill deficiencies. Neither does the analysis of the relationships between accident site and tow characteristics.

This general conclusion is qualified with respect to collisions, where a sizable subset was found that might possibly have been avoided by effective use of bridge-to-bridge radiotelephone, even though the navigational situation was not an easy one. Another possible qualification is suggested concerning the use of radar. Poor visibility necessitating radar navigation, was cited as a causal factor in relatively few cases (less than 10% for each type of accident). However, radar navigation might have been helpful in other cases, in assessing the collision threat, position fixing, and determining navigational distances. It was found that on 37% of the towboats in the study the radar was not on or was not working properly.

The results of this study indicate that the predominant clusters of accidents on the Western Rivers and the Gulf Intracoastal Waterway are generated by the navigational situation. Accidents tend to occur when circumstances coverge to create a ticklish maneuvering situation. Given the sources of information and the control mechanisms available to pilots, successful passage cannot be guaranteed.

It is concluded that the major human factors problems in tow control are:

- inadequate sources of precise, timely information about environmental forces, especially current; and
- uncertainty about the response to control actions, as affected by tow dimensions and loading, under various combinations of channel characteristics and environmental disturbances...

when the maneuvering restrictions are such as to allow little margin for error.

There is also evidence to suggest that the inherent maneuverability of the vessels may tend to be insufficient in certain locales and time periods. Although the measures of horsepower versus load indicate that on the average, power capability should have been adequate, at least according to present guidelines, additional power might have prevented some of the accidents studied. This is not entirely clear, however. Other factors must be evaluated, such as the lag in pilot perception that the vessel is getting out of alignment and the available recovering distance.

CONCLUSIONS ABOUT SAFETY ACTIONS

The potential remedies for the safety problems identified in this study are of four kinds:

- Alteration of the environment
- Alteration of the vessels and equipment
- Alteration of the personnel
- Alteration of operating procedures.

Alteration of the environment would be the most direct and potentially the most effective remedy; and it is the only one of the four which taken alone, might lead to significant safety gains. This is because environmental change could eliminate or mitigate hazards to navigation. Alterations of vessel, equipment, personnel, and procedure could allow the hazards to be coped with

more effectively; but in some of the common accident situations, to expect significant improvements by such means alone appears to be unrealistic. This is not so much because of the state of the art as because of the costs and sociopolitical disturbances that may be involved. In addition, operating practices might be altered in response to environmental improvements, in such a way as to bring the risk level back up. Probably it is best to try to alter all four aspects of the systems in complimentary ways. Some specific safety actions of each kind are recommended, taking into account both potential effectiveness and feasibility.

RECOMMENDATIONS

Environmental Solutions

The goal is to minimize channel obstructions. Piers and mooring areas, grounded vessels, submerged structures such as the remains of an old lock, silting and mud deposits, as well as bridges and locks in use, permanently or temporarily reduce the available channel width where accidents tend to occur. Specific problems which should be addressed are identified below.

A systematic procedure is needed to analyze the placement and construction of bridges in relation to navigational requirements. While it is recognized that bridges are land-traffic oriented, they are the most prominent hazard in river accidents, and water traffic problems must be emphased. Among the parameters that must be considered are:

- Span
- Location and orientation
- Current patterns - without bends where possible
- Type of bridge.

The Conference Report on the Surface Transportation Assistance Act of 1978 (Report No. 95-1797) includes provisions for the acceleration of bridge projects (Sec. 147). The Secretary of Transportation is called upon to initiate projects...

> to construct or replace high traffic volume bridges located on the Federal-aid system and which traverse major bodies of water in

order to demonstrate the feasibility of reducing the time required to replace unsafe bridges.

Such projects would provide an excellent opportunity to demonstrate concern for marine safety in the planning of any new bridge and to demonstrate a procedure for including marine safety considerations in design optimization.

With regard to locks, accidents were attributed to new lock construction and to old lock discontinuation or dismantling. Although this particular form of hazard was not in itself excessively frequent (it is included in "submerged/uncharted hazard," and "other vessels" or obstacle(s) limited maneuvering options"), it is a subset of the large class of accidents involving channel impediments. A similar kind of problem, also found among the accident cases, is with old bridge piers. When a bridge is placed out of service, it should be removed totally, including the piers.

In addition, the poor detectability of bridge piers should be corrected. The use of radar transponders has been suggested as well as the simple solution of marking with reflective material.

Finally, and more generally, the Coast Guard should, in cooperation with the Corps of Engineers, take an inventory of the obstacles present in areas where accidents are frequent and determine what would be required to eliminate them.

The Congressional Committee Report cited above includes the following language amending Section 152, Title 23, of the United States Code to require each state to...

> conduct and systematically maintain an engineering survey of all public roads to identify hazardous locations, sections and elements,...assign priorities for the correction of such (sites), and establish and implement a schedule of projects for their improvement.

Similar philosophy and action are needed for the waterway system.

Even though immediate corrective action might not be possible, improvement plans may be made. The siting of facilities, even marine facilities, has occurred over time, apparently with little eye to the development of vessel operations. That is, integrated planning to facilitate the safe movement of

vessel traffic appears to have been insufficient in the past. That insufficiency should be made up. Certainly no new facilities should be introduced without careful consideration of the effects on vessel movement through an area. Although the Corps of Engineers has responsibility for waterway improvements (including responsibility for issuing permits for new facilities) the Coast Guard should be closely involved in evaluating the possible safety impacts of any new proposal.

Vessel and Equipment Solutions

An investigation should be undertaken to determine the positive and negative aspects of increasing the horsepower-to-barge or tonnage ratio in the accident scenarios of this study. It is known that the towboats lack control but it is not clear that additional horsepower will necessarily solve the problem given the available maneuvering area and spatial relationships. An analytic study should be undertaken to clarify the vessel behavior for different conbinations of horsepower, tow dimensions, and cargo deadweight, with various combinations of environmental constraints and forces. Concepts toward such a study were presented in Volume I of the previous Analysis of Bridge Collision Incidents performed by ORI, Inc. (NTIS AD A029034, May 1976).

It would be useful in designing such a study to compare the typical characteristics of the vessels in accidents to those of the operating population. This would require a substantial data development effort, however, unless Corps of Engineers data on tow characteristics will serve. Those data have not been computerized for ready analysis, but it is reported that the Corps is now undertaking the necessary coding and software preparation.

An analytical modeling effort might be preceded by experimentation to focus the effort. Actual trials might be considered in which the vessel's deviation from intended track is measured. This should not raise questions of jeopardizing participants so long as the research does not dictate the tow makeup, loading and routes; the research must only observe and measure. Follow-up experimentation involving research control might be conducted through real-time simulation.

Follow-up experimentation involving research control, might be conducted through real-time simulation.

Aids to navigation on the approaches to bridges, especially, need to be improved. Aids should be positioned, insofar as the area physical features allow, to enable a pilot to line up with the greatest possible accuracy. Added lights on buoys should be considered to assist nighttime navigation. In addition, the use of radar transponders on major aids should be considered. It may be desirable to design a special system of aids to help resolve the special problems of passage through bridges, especially where the approach includes a bend.

It would also be desirable to investigate the feasibility of an electronic information/guidance system and alarms to warn of excessive slide and rotation.

Personnel and Procedural Solutions

The apparent deficiencies in vessel-to-vessel communications and in vessel communications with movable bridge stations should be investigated. It may be necessary to modify the Bridge-to-Bridge Radiotelephone Regulations to require rather than just to suggest the practice of broadcast calls in blind situations. Along with any requirement, guidance for effective communication should be offered. The development of such guidance should not be a casual undertaking. It should involve operating personnel in elaborating the scenarios identified in this study, to define more specifically situations in which collisions and near misses might be avoided by better communications and to define the specific kinds of information that should be exchanged.

In some highly confined areas, some form of traffic control might be necessary to make significant inroads on the accident rates. Pilots have told us that the traffic advisory services, with voluntary participation by vessels, may be worse than no service. The advisory system may create a sense of security that hazards, especially the movement of other vessels, are well known, so that wariness may be relaxed.

It would be desirable to consider development of a real-time simulator trainer for inland waters navigation. The ability to maintain controllability in the changing situations on the rivers (e.g., river stage; changing current patterns within a river segment, particularly at bends; bridges, fixed and movable; locks) is clearly in on-the-job learning process which might be complemented by systematic training procedures in which repetitive runs could be made in various situations that can arise in transiting the inland waters over an extended period of time. The benefits of more precise information about upcoming hazards, especially currents and winds might be tested on the training simulator.

To test the study findings concerning personnel competency, it would be useful to gather additional information about personnel characteristics for comparisons of those involved in accidents to all active personnel. The following items of information are suggested that were not available in the accident reports:

- Time on vessel
- Experience on vessel
- Experience on river
- Experience with particular company.

A FINAL COMMENT ON ACCIDENT RATES, AND SEVERITY AND THE JUSTIFICATION OF SAFETY ACTIONS

Accident rates in tow operations have been found to be low compared to other commodity transport modes and considering the total waterway system studied as a whole. Using the data in Appendix A, rough estimates of rates were produced, ranging from roughly .0002 accidents per transit to .0008 per transit. (These rates correspond to the nondimensional scale of accidents/traffic density shown in Figure 1.1 and in the complete set of such figures in Appendix A.)

Further, the damage cost data (Section III, pages 94-102) suggest that the consequences of towboat-barge accidents tend to be relatively modest.

While these circumstances are fortunate, they tend to diminish the urgency of actions to correct safety problems. Moreover, the problems identified in this study are for the most part not easy to solve. Convenient procedural adjustments and rules are not noted for effectiveness in any problem area, and they certainly do not appear useful in the present case.

The impetus for concern, and, more importantly for action, is in the potential for catastrophic consequences that is ever present, at least in a system in which hazardous commodities are being moved. The calculated probabilities, based on historical data of various quality and applicability are usually very low. But few who have responsibility for an aspect of public safety are willing to assert that the risk level is acceptable.

In general, any of the comparatively minor accidents in the study sample might have been a major accident. A dramatic example is the case of barge SCC-620, loaded with 640 tons of chlorine, which went onto a dam near downtown Louisville, Kentucky. Through an extraordinary rescue effort using helicopters and cranes, the barge was extricated from its perch, halfway over the dam, without further mishap. The lives of a few hundred to several thousand people rested on the success of that rescue operation. This kind of potential is the reason for acting upon hazards before they are written into history.

APPENDIX A
ACCIDENT RATE CHARTS

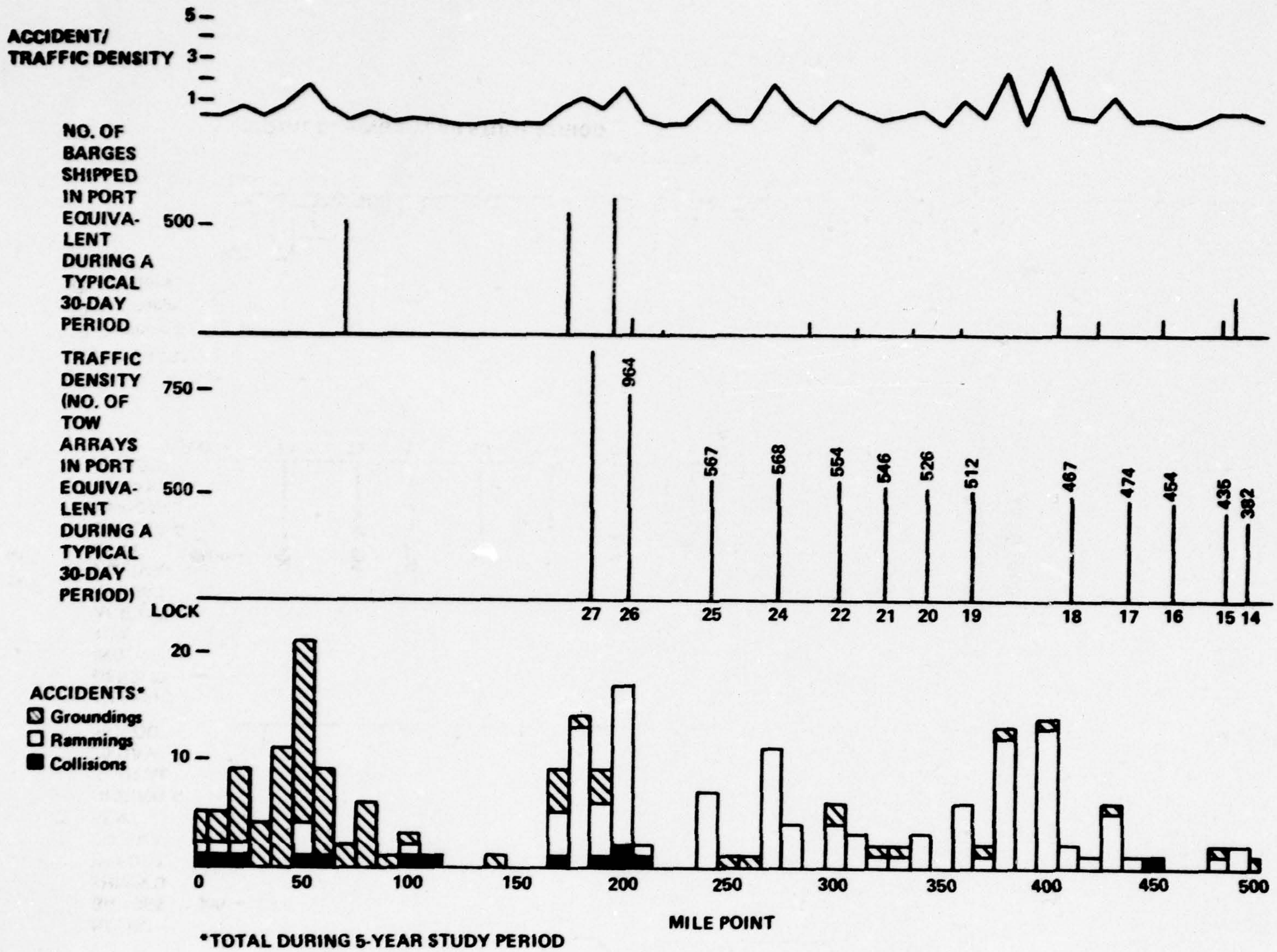

FIGURE A.1. TRAFFIC VERSUS ACCIDENTS,
UPPER MISSISSIPPI RIVER

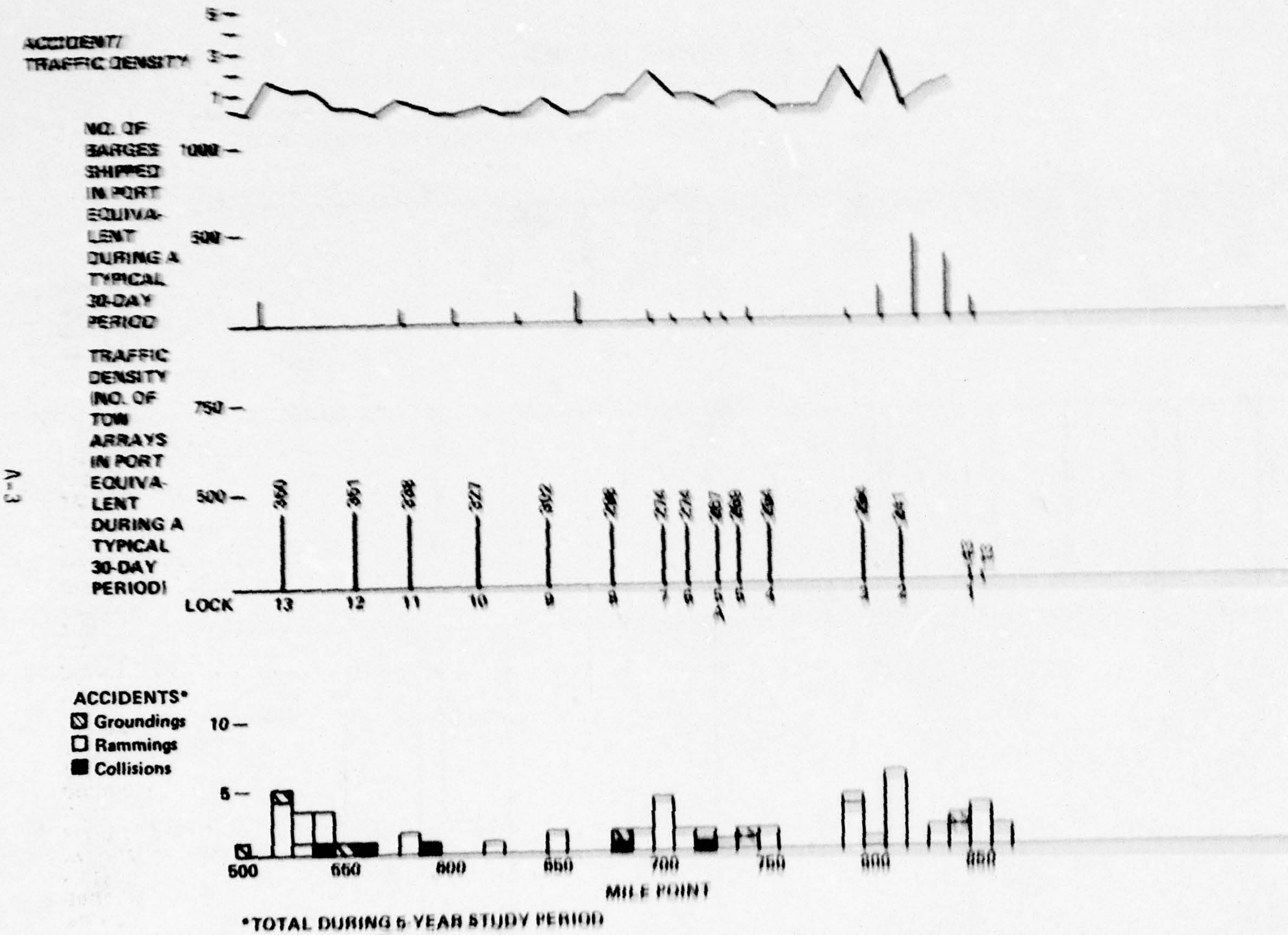

FIGURE A.1 (CONT.)

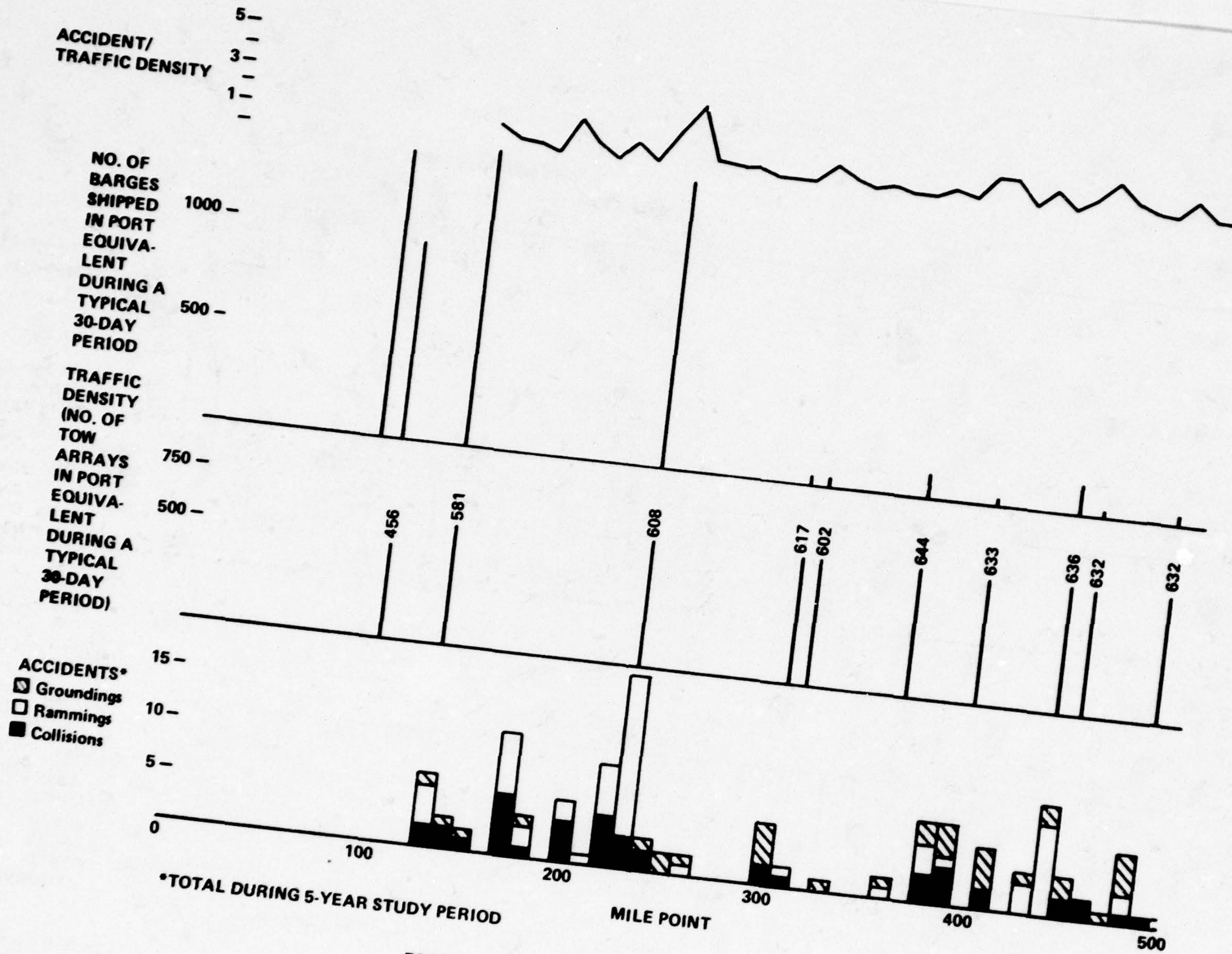

FIGURE A.2. TRAFFIC VERSUS ACCIDENTS
LOWER MISSISSIPPI RIVER

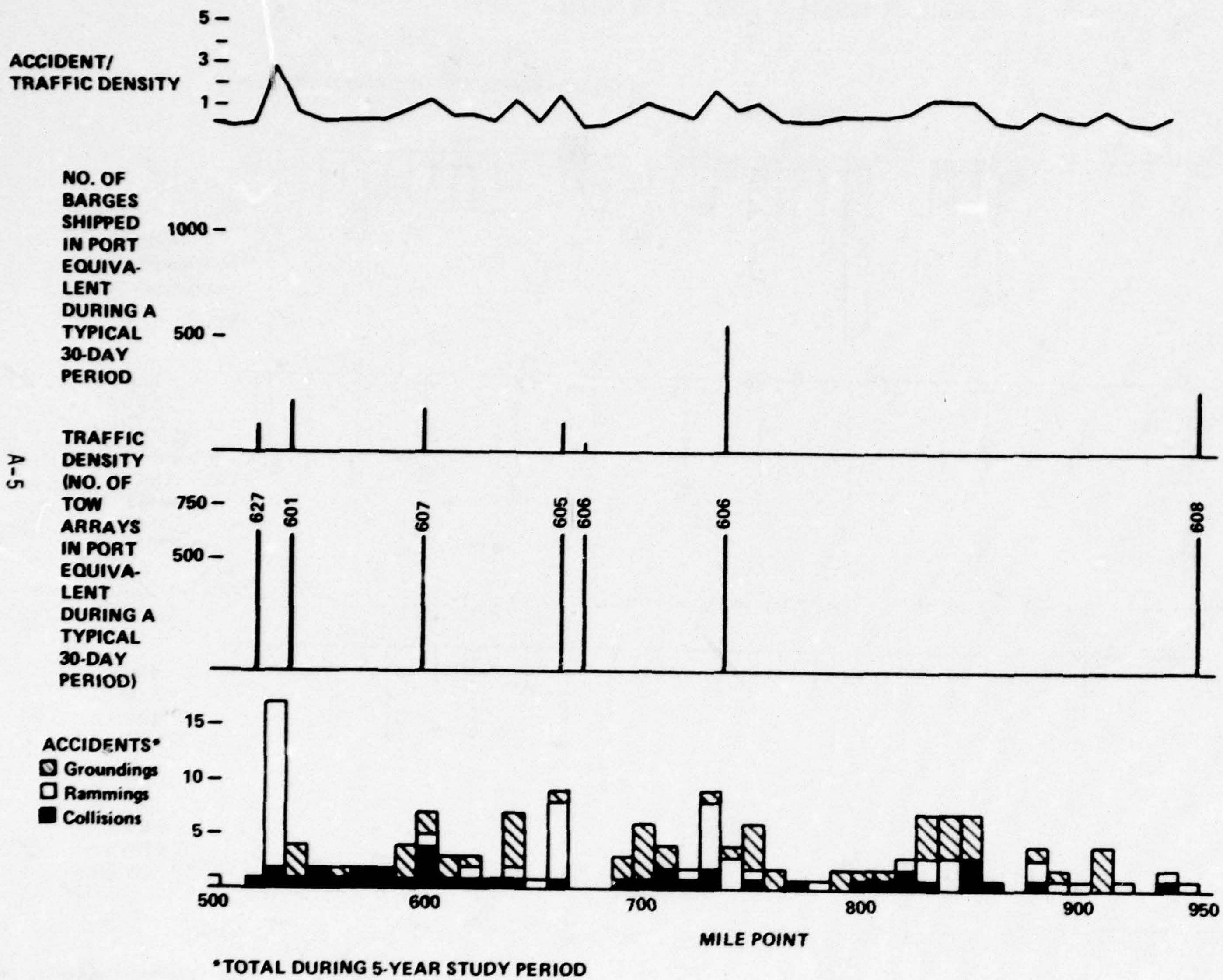

FIGURE A.2 (CONT.)

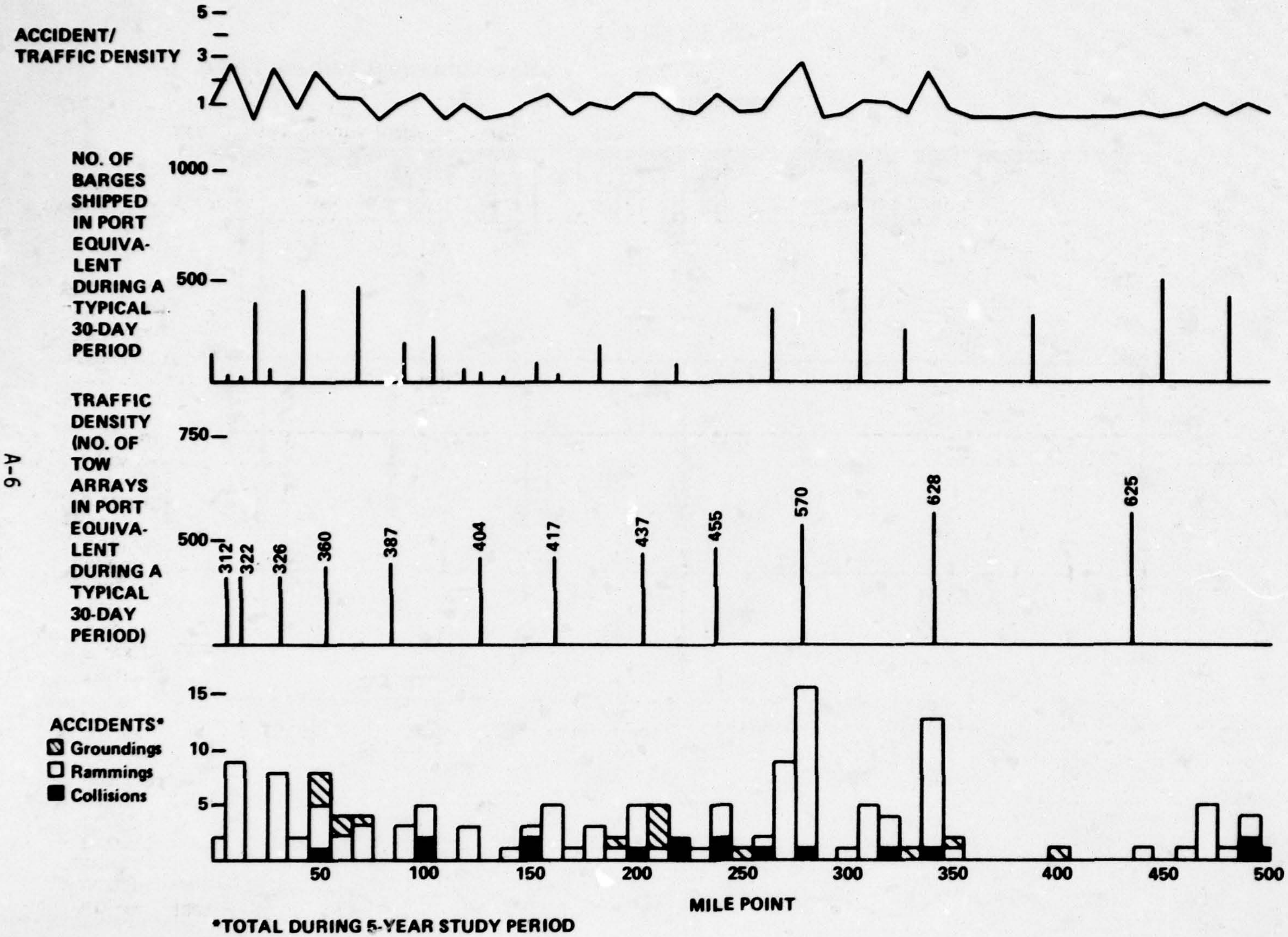

FIGURE A.3. TRAFFIC VERSUS ACCIDENTS
OHIO RIVER

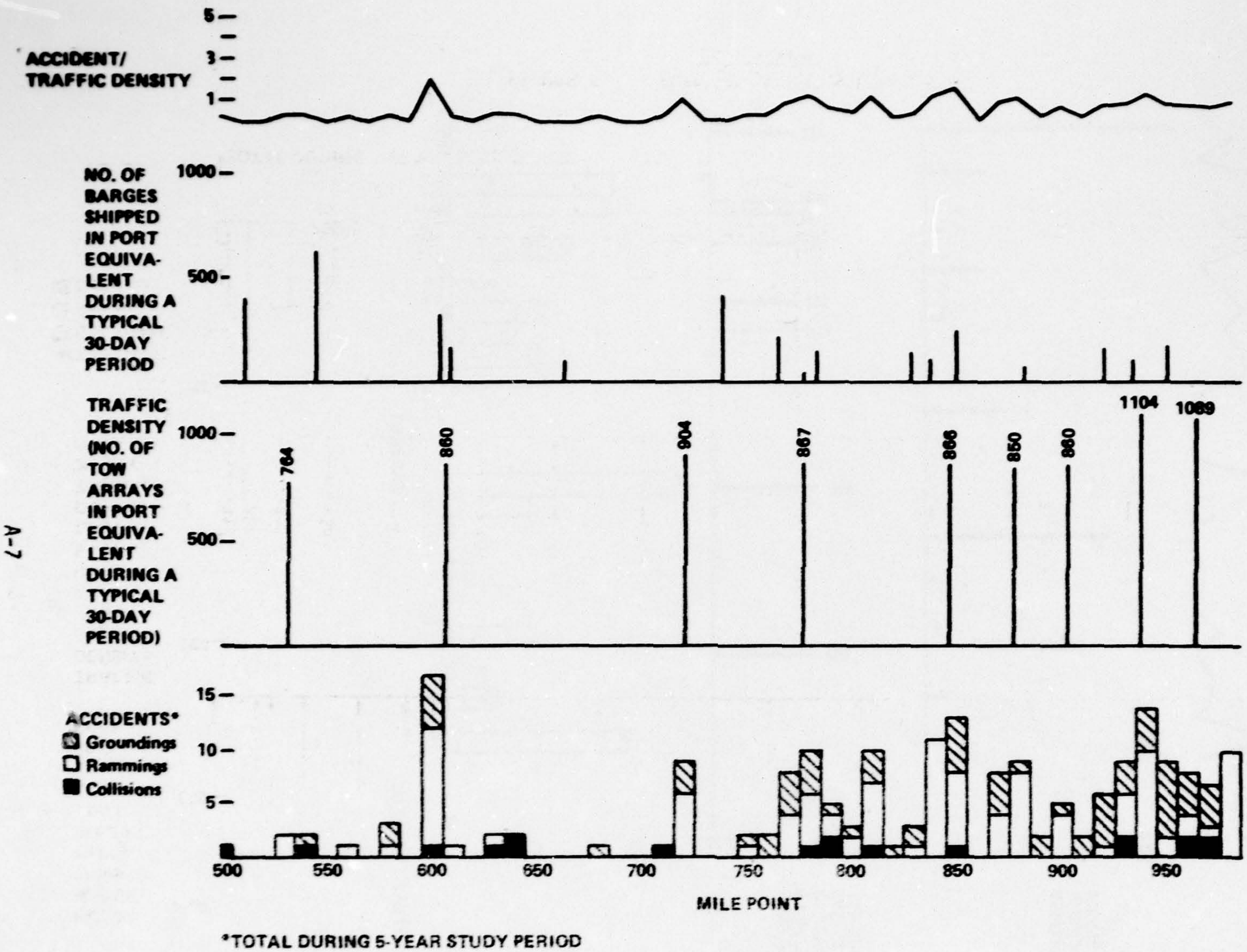

FIGURE A.3 (CONT)

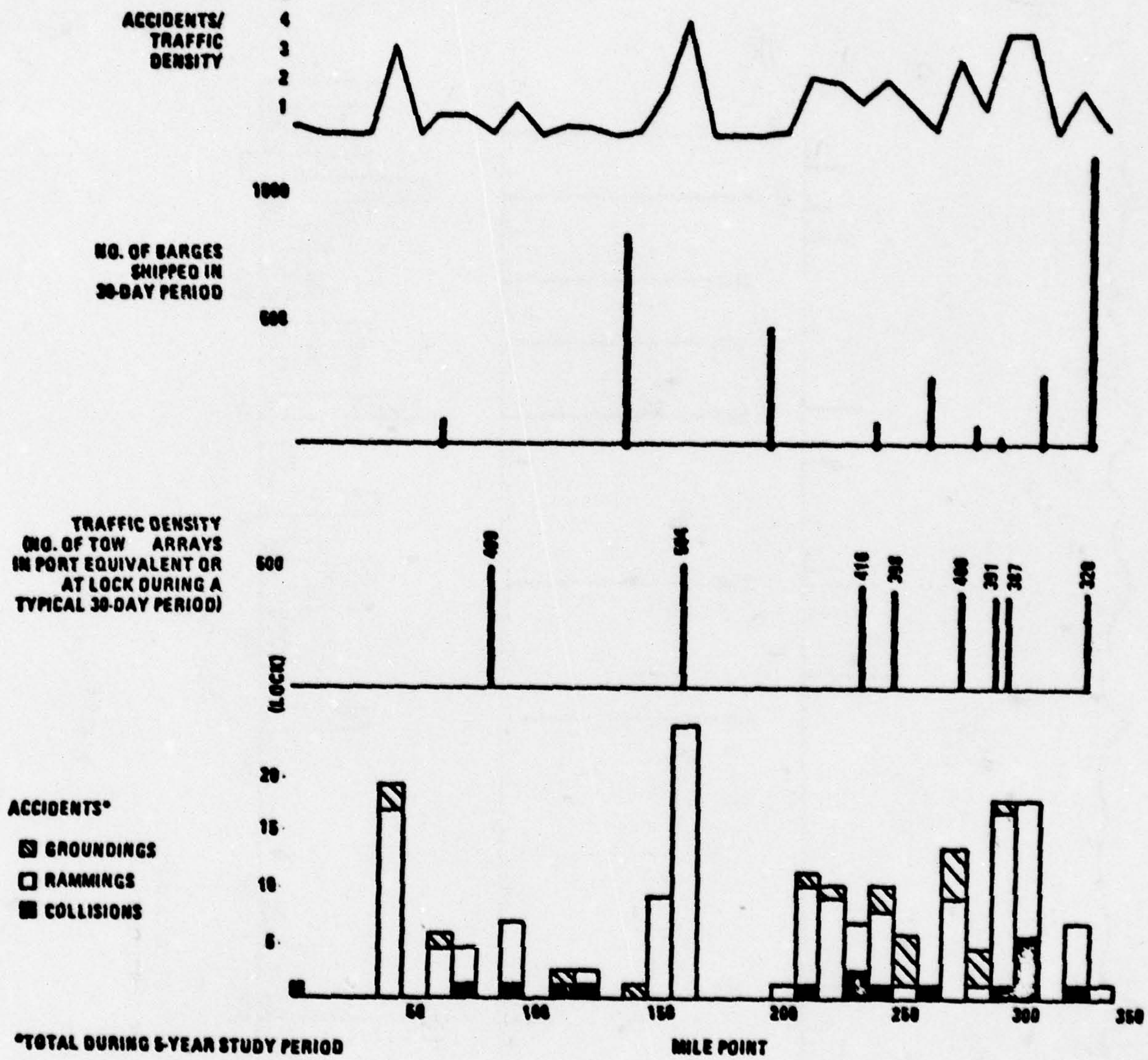

FIGURE A.4. TRAFFIC VERSUS ACCIDENTS
ILLINOIS WATERWAY

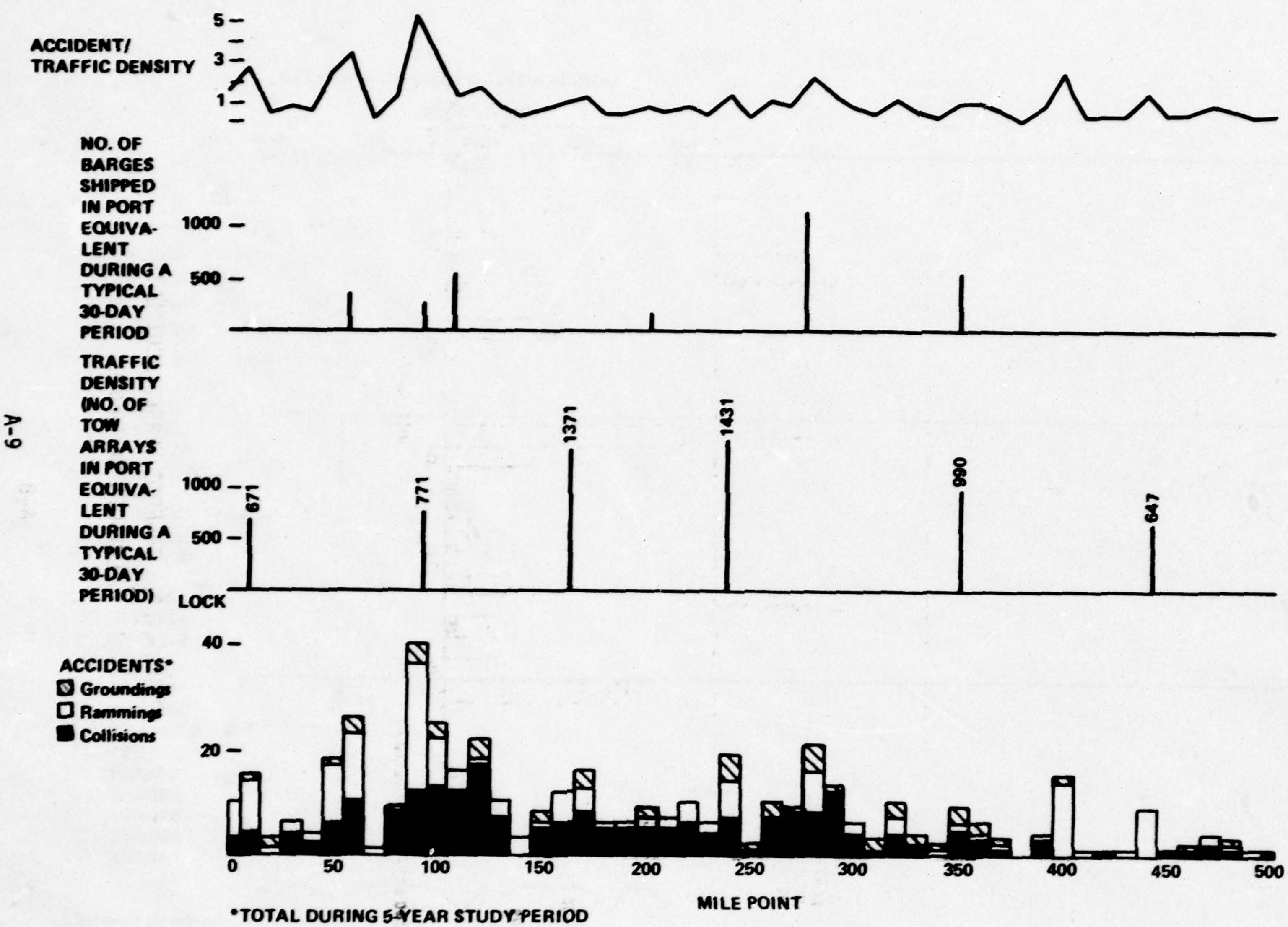

FIGURE A.5. TRAFFIC VERSUS ACCIDENTS
GULF INTRACOASTAL WATERWAY, WEST

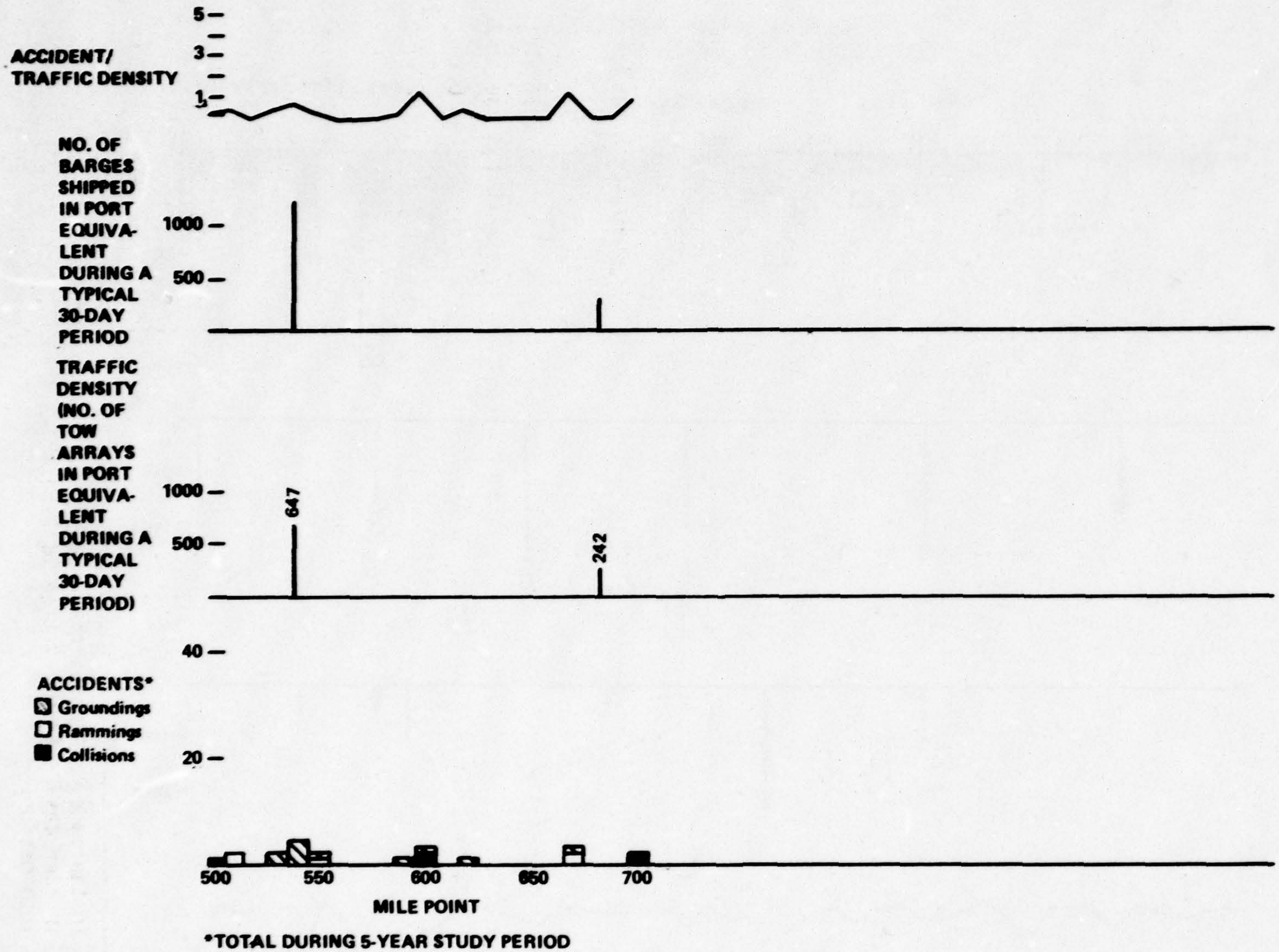

FIGURE A.5. (CONT).

APPENDIX B

TOWBOAT ACCIDENT QUESTIONNAIRE

GENERAL INSTRUCTIONS

A. Materials required:

1. 2692 and towboat addendum, (where available)
2. Chart of river segment
3. List of towboat and barge companies.

B. If answer to question cannot be determined from materials, place the number "9" in each "block" of that answer on the answer sheet.*

C. As answers may contain fewer digits than blocks provided for the potential answer, care must be taken to ensure that "right justified" procedure is followed; i.e., if four blocks are provided, but the answer is, for example, two digits, as in 25, then 25 would be written 0025.

---

* In the case of towboat characteristics, horsepower should be gotten in each case. If not available in "2692," then ECO will supply information.

1. Case Number — 1 2 3 4 5

b
6

2. Official Number — 7 8 9 10 11 12

b
13

3. Date of Casualty — 14 15 16 17 18 19
Mon Day Yr

b*
20

4. Type of Casualty

11 Overtaking collision of two or more separate, underway vessels
12 Crossing " " " " " " " "
13 Head on " " " " " " " "
14 Other " " " " " " " "
21 Bridge ramming
22 Dike "
23 Lock/dam "
24 Dock "
25 Other "
31 Ramming of another vessel anchored or moored
41 Grounding
51 Other

21 22

b
23

*b = blank

5. River Location of Casualty

1. Lower Mississippi River head of passes to MP 125
2. Lower Mississippi River Mile Point 125 to Cairo, Illinois
3. Upper Mississippi
4. Ohio
5. Illinois Waterway
6. Gulf Intracoastal Waterway West

$\overline{24}$

$\frac{b}{25}$

6. Milepoint Location of Casualty (To nearest tenth of mile) $\overline{26}\ \overline{27}\ \overline{28}\ \overline{29}\ \overline{30}$

$\frac{b}{31}$

7. Age of Operator $\overline{32}\ \overline{33}$

$\frac{b}{34}$

8. Date of Birth of Operator $\overline{35}\ \overline{36}$ (Mon) $\overline{37}\ \overline{38}$ (Day) $\overline{39}\ \overline{40}$ (Yr)

$\frac{b}{41}$

9. Years of Experience of Operator as Person in Charge $\overline{42}\ \overline{43}$

$\frac{b}{44}$

10. Number of Hours on Duty Prior to Casualty to Nearest Tenth of Hour $\overline{45}\ \overline{46}\ \overline{47}\ \overline{48}$

$\frac{b}{49}$

Towboat Characteristics

11. Gross Tonnage of Towboat — 50 51 52 53

    b / 54

12. Length of Towboat — 55 56 57

    b / 58

13. Horsepower of Towboat — 59 60 61 62 63

    b / 64

14. Number of Propellors — 65

    b / 66

15. Was Towboat Equipped with Flanking Rudders? — 67

    Yes - 1

    No - 0

    b / 68

16. Was Equipment/Machinery Failure a Contributing Factor in Casualty? — 69

    No - 0

    Yes - 1

    b / 70

17. Maximum Draft of Towboat (To nearest tenth of foot) — 71 72 73 74

    b / 75

18. Year Built of Towboat (Last two digits only) — 76 77

    Card Number 1 — 1 / 80

19. Case Number — 1 2 3 4 5

b
6

20. Official Number — 7 8 9 10 11 12

b
13

21. Direction of Movement of Tow Array — 14

- Upriver - 1
- Downriver - 2
- Not applicable - 3

b
15

22. Configuration of Tow Array — 16

- Pushing ahead - 1
- Pulling astern - 2
- Hip breast tow - 3
- Other - 4

b
17

23. Number of Barges in Array — 18 19

b
20

24. Number of Loaded Barges — 21 22

b
23

25. Number of Light Barges — 24 25

b
26

26. Total Cargo Tonnage — 27 28 29 30 31

b
32

27. Overall Tow Array Length Including Towboat — 33 34 35 36

b
37

28. Overall Tow Array Width Including Towboat — 38 39 40

b 41

29. Maximum Draft of Any Barge in Array to Nearest Tenth of Foot — 42 43 44 45

b 46

River Characteristics

30. Available Channel Width — 47 48 49 50

At lock, enter lock width (except on GIWW & Upper Miss. & Upper Ohio, single lock will be 0110; double will be 0220).

b 51

31. Is there indication of high water or low water? — 52 53

High water - 01
Low water - 02

b 54

32. From chart, fill in the following information occurring within 1/2 Mile on either side of the casualty (cannot code 9); 8 indicates 8 or more:

Number of fixed span bridges	55
" " movable " "	56
" " locks/dams	57
" " dikes	58
" " bends	59
" " bars and/or islands and/or rocks	60
" " docks - 8 indicates 8 or more	61
" " man-made structures	62
" " canal or navigable rivers	63
" " major port (must be 1 if #61 is 8)	64

b 65

33. Maximum Clear Span of Struck Bridge (000 if not applicable) — 66 67 68

34. Time of Day Casualty — $\overline{69}$

Day - 1
Night - 2
Twilight - 3

35. Visibility at Time of Casualty — $\overline{70}$

Less than 1/4 mi. - 1
1/4 to 1/2 - 2
1/2 to 1 - 3
1 to 2 - 4
Greater than 2 mi.- 5

36. Wind Speed at Time of Casualty — $\overline{71}$ $\overline{72}$

37. Weather at Time of Casualty — $\overline{73}$

Clear - 1
Partly Cloudy - 2
Overcast - 3
Fog - 4
Rain - 5
Snow - 6
Other - 7

$\frac{b}{74}$

38. Wind Direction at Time of Accident — $\overline{75}$ $\overline{76}$ $\overline{77}$

39. Was radar on board? — $\overline{78}$

Yes - 1
No - 0
Yes, but not turned on - 2
Yes, but not operating properly - 3

40. Was bridge-to-bridge radio telephone used? — $\overline{79}$

No - 0
Yes- 1
Yes, but not properly - 2
Secondary vessel not involved - 3

Card 2 — $\frac{2}{80}$

APPENDIX C

CHART EXPLANATION SHEETS

TABLE OF CONTENTS

CHARTLET EXPLANATION SHEETS

TABLE OF CONTENTS (Cont.)

INTRODUCTION

This volume presents data obtained from the study sample of accident reports and locations. The sample included accidents on the Upper and Lower Mississippi, the Ohio River, the Illinois Waterway, and the Gulf Intracoastal Waterway (GIWW), East and West, in which the primary vessel was a towing vessel with one or more barges. All accidents in 35 10-mile segments were studied. The segments were those in which 10 or more accidents occurred during the 5-year study period, plus 5 segments that did not have 10 accidents, but were high accident areas in relation to traffic density.

A questionnaire was used in the extraction of pertinent information from the accident reports. Accident identification, towboat/barge characteristics, river characteristics, environmental conditions, and towboat operator information were topics covered in the questionnaire, which is presented in Appendix B.

This appendix contains additional information on "Chart Explanation Sheets" derived by examining the accident reports in relation to the charts of the locations where the accidents occurred. Area characteristics usually are not described in any detail, if at all, in the reports. Seeing the sites provided the study personnel with a better understanding of the causal factors cited in the reports.

References are provided on the first Chart Explanation Sheet in each set to navigational charts for each segment. Charts may be obtained from the U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Ocean Survey.

CHART EXPLANATION SHEETS
LOWER MISSISSIPPI RIVER

MILE SEGMENT 170 (165-175)

LOWER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	41201	05-07-73	1	DN	171	Ramming moored vessel. Strong winds and current rounding bend.
R2	41998	05-21-73	24	DN	170	Ramming moored vessel. Strong winds and current rounding bend.
R3	41962	05-28-73	19	DN	171	Rammed moored vessel rounding bend in strong current.
C1	22092	01-30-72	3	DN	173	Mix-up in passing information. Head-on collision in bend.
C2	22285	11-16-71	45	UP	172.8	Mix-up in passing information. Head-on collision in bend.
C3	30197	04-15-72	3	UP	173	Failure to keep to right in sharp bend. Head-on collision.
C4	43142	02-06-74	2	UP	174	Tow backed out from pier into path of upbound tow. Crossing collision.

MILE SEGMENT 220 (215 - 225)

LOWER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	52578	03-14-75	4	UP	224	Towboat helping another tow to shape up inadvertently damaged a barge.
R2	60743	09-14-75	21	DN	217	Misjudged stopping distance. Hit barge.
R3	32267	02-11-73	2	DN	227	Lost control attempting to dodge loose barges. Collided with anchored vessel.
R4	32294	11-30-72	22	DN	226	Tow could not avoid freighter swinging at anchor in current.
C1	52623	03-03-75	24	UP	214	Rounding bend, tow sheered in front of and collided with downbound tow.
C2	61688	10-30-75	17	UP	222	Passing tows (head-on) collided in bend. Had passing agreement, but neither over to side far enought. Both operators erred.
C3	43266	04-06-74	23	DN	221.5	Passing tows (head-on) collided in bend. Confused passing agreement. Both operators erred.

MILE SEGMENT 230 (225-235)

LOWER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	31705	11-23-72	UNK	DN	230	Out of shape in bend in current. Hit Highway Bridge 190.
R2	31758	12-24-72	3	DN	231	Out of shape in current in bend. Hit Highway Bridge 190.
R3	31707	11-12-72	25	DN	231	Maneuvering to dock, current too strong for horsepower. Set into moored barge.
R4	32209	02-21-73	1	UNK	230.1	Maneuvering to tie off tow. Hit moored barge.
R5	21217	12-18-71	16	DN	233.9	Overcompensated for cross current. Hit bridge.
R6	60848	07-19-75	13	UNK	227.3	Maneuvering to make up tow. Hit barge
R7	50501	06-15-74	23	DN	227.8	Out of shape in current. Hit moored vessel.

MILE SEGMENT 230 (225-235)

LOWER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R8	50669	08-18-74	2	UNK	232	Out of shape in current. Hit moored vessel.
R9	51289	06-23-74	4	DN	228	Out of shape in current. Hit moored vessel.
R10	41930	12-24-73	4	DN	226	Struck anchored ship. Fog.
R11	43009	01-04-73	2	UNK	233.9	Hit bridge. One engine inoperative.
G1	31701	02-09-73	UNK	UNK	230	Maneuvering to make up tow. Wind and current forced into adjacent tow.
G2	63298	04-24-76	UNK	UNK	231	Struck submerged dolphin.
C1	42340	12-18-73	4	DN	226	Failure to reach passing agreement. Collision.

MILE SEGMENT 440 (435-445)

LOWER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	60496	03-05-75	4	DN	435.7	Strong current. Hit Vicksburg Bridge.
R2	43007	06-04-74	4	UP	435.8	Cross current. Hit Vicksburg Bridge.
R3	42179	05-22-73	UNK	DN	435.8	Strong cross current. Hit Vicksburg Bridge.
R4	31960	12-31-72	UNK	DN	435.8	Strong cross current. Hit Vicksburg Bridge.
R5	32973	04-01-73	5	DN	436	Strong current. Out shape in bend. Hit Vicksburg Bridge. Six missing.
R6	42899	12-24-73	4	UP	435.8	Swift current topped tow into Vicksburg Bridge.
G1	52408	03-08-75	1	UP	436.1	While docking, current topped tow into rock ledge.
G2	30084	01-27-72	4	DN	446	Grounding. Rounding bend. Strong current. Fog.

MILE SEGMENT 530 (525-535)

LOWER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	61457	01-26-76	UNK	DN	531.3	Strong current - out of shape; hit Greenville Bridge.
R2	42538	02-03-74	2	DN	531.3	Strong current and wind - barges light - out of shape; hit Greenville Bridge.
R3	32367	02-13-73	24	DN	531.3	Strong current - out of shape - fog night; hit Greenville Bridge.
R4	22062	06-04-72	25	DN	531.3	Towing wire broke - probably due to violent manuevers to get in shape; hit Greenville Bridge.
R5	51445	01-01-75	10	DN	531.3	Strong currents and winds - tow slid into bridge pier.
R6	21512	01-17-72	6	DN	531.3	Strong current - out of shape; hit Greenville Bridge.
R7	41969	01-25-74	9	DN	531.3	Wind and strong current - out of shape; hit Greenville Bridge.

MILE SEGMENT (525-535)

LOWER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R8	52665	04-07-75	25	DN	531.3	Strong current - out of shape; hit Greenville Bridge.
R9	51120	11-16-74	30	DN	531.3	Poor visibility plus strong current; hit Greenville Bridge.
R10	32154	01-01-73	4	DN	531.3	Strong current and cross wind forced tow into Greenville Bridge pier.
R11	51816	02-09-75	28	DN	531.3	Strong current - out of shape; hit Greenville Bridge.
R12	41565	04-28-73	25	DN	531.3	Strong current; hit Greenville Bridge
R13	51757	02-05-75	21	DN	531.3	Strong current; hit Greenville Bridge
R14	32088	11-27-72	3	DN	531.3	Gusty winds; hit Greenville Bridge.
R15	52114	03-26-75	28	DN	531.3	Strong current; hit Greenville Bridge
C1	22122	03-10-72	25	DN	534.3	Passing tows did not keep to right; head-on collision.

CHART EXPLANATION SHEETS
UPPER MISSISSIPPI RIVER

MILE SEGMENT 040 (035-045)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	60508	07-30-74	20	DN	43.7	Maneuvering to get in shape for Thebes Bridge broke towing wire and barge hit bridge pier.
R2	60673	04-29-75	24	DN	43.7	Out of shape at Thebes Bridge; struck pier.
R3	62626	05-12-76	UNK	DN	44.0	Maneuvering to line up for Thebes Bridge - broke towing gear; hit bridge.
G1	51121	09-29-74	4	DN	43.0	Grounded in low water.
G2	50982	09-09-74	4	DN	42.9	Struck unidentified submerged object.
G3	51439	10-24-74	15	UP	43.5	Struck unidentified submerged object.
G4	63247	08-20-76	UNK	DN	42.7	Stopped to avoid tow ahead; grounded.
G5	63341	08-15-76	UNK	DN	38.0	Hit bottom in low water.
G6	63176	06-17-76	UNK	UP	43.7	Out of shape through bridge; grounded.
G7	64213	09-10-76	UNK	DN	37.5	Grounded during low water.

MILE SEGMENT 050 (045-055)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	52462	02-19-75	12	DN	45.6	Pilot unaware of grounded barge in his way; ran into it.
G1	51413	10-9-74	15	UP (2)	46.0	Low water allowed barge to ground.
C1	50433	07-25-73	4	UP	48.0	Passing vessel swung in front of tow causing collision.
G2	51873	11-08-74	3	UP (1)	46.0	Water in fuel, loss of power, grounding on rock dike.
G3	51441	09-22-74	20	DN (2)	46.6	Low water allowed tow to ground and break up.
G4	52153	12-10-74	12	DN	54.5	Pilot missed the channel while negotiating bend; grounded.
G5	51748	01-10-75	21	DN	46.0	Pilot misjudged width of channel and grounded.
G6	51448	12-08-74	3	DN	46.0	Pilot misjudged effects of current and couldn't manuver around point; grounded.

MILE SEGMENT 050 (045-055)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
G7	51991	02-19-75	15	DN	46.0	Pilot misjudged width of channel and grounded.
G8	51732	01-29-75	3	DN	46.2	Pilot misjudged wind and current and grounded.
R2	31747	11-19-72	UNK	UP	51.6	Pilot misjudged high water and strong current; hit barge.
G9	32694	02-16-73	24	DN	51.6	Maneuvering for bridge broke towing wires; grounded.
G10	31955	11-23-72	UNK	DN	55.0	Got out of shape in strong current in bend; grounded.
G11	42029	01-09-74	16	DN	49.0	Leaking barge and ice buildup; grounded.
G12	61614	02-10-76	UNK	DN	45.2	Error in judgment while flanking bend - ran aground; misjudged current

MILE SEGMENT 050 (045-055)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R3	61613	11-05-75	UNK	DN	46.5	Attempt to tie off at bank in fog - tow grounded and rotated in current, colliding with other anchored barges.
G13	61097	11-02-75	UNK	DN	46.0	Lost control while flanking bend; grounded.
G14	63164	07-21-76	UNK	UP	47.1	Grounded in low water.
G15	64193	09-16-76	UNK	DN	49.8	Current in bend caused grounding in narrow channel.
R4	64214	09-16-76	UNK	DN	49.8	Tow misaligned in channel and collided with moored barge.

MILE SEGMENT 180 (175-185)
UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	63773	07-04-76	UNK	UNK (3)	177.0	Operator lost control while dropping off single barge - ramming moored vessel.
R2	62924	03-28-76	UNK	DN (2)	179.2	Operator misjudged current & rammed bridge.
R3	61389	02-03-76	3	DN	180.2	Steering equipment failed; rammed bridge.
R4	62069	03-06-76	UNK	DN	182.0	High winds and strong current caused breakup of tow which then rammed bridge.
R5	60481	09-28-75	UNK	DN	180.0	Lookout failed to warn in time of proximity of bridge; hit bridge.
R6	62625	03-12-76	2	DN	180.0	Operator misjudged current; rammed bridge.
R7	52252	01-29-75	1	NA	176.1	Misjudged approach speed and bumped mooring too hard.

MILE SEGMENT 180 (175-185)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R8	32891	02-18-73	4	DN	180.0	Misjudged wind and current; forced into bridge pier.
R9	21010	11-03-71	12	DN	183.2	Misjudged approach; after part of tow did not clear bridge.
R10	32876	03-01-73	1	DN	178.0	Pilot failed to see moored barges; hit barge.
R11	52829	03-07-75	11	DN	179.2	Operator had too little horsepower for size of tow; lost control in current; rammed bridge.

MILE SEGMENT 200 (195-205)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	31666	04-10-72	UNK	UNK	203	Reduction gear failure - hit lock gate.
R2	51230	08-21-74	15	UP	202.9	Struck piling at lock entrance.
R3	30983	06-02-72	4	UP	202.6	Outdraft set tow into lock wall.
R4	40408	06-14-73	5	UP	203	Outdraft set tow into lock wall.
R5	31592	11-15-72	9	UNK	202.9	Hit lock piling while manuevering.
R6	51992	03-25-75	UNK	UNK	197.0	High wind pushed tow into dock.
R7	42671	11-24-73	3	DN	203	Outdraft set tow into lock wall.
R8	51602	07-20-74	4	DN	203	Misjudged stopping distance - hit lock wall.
R9	43220	11-28-73	14	UP	203	Misjudged stopping distance - hit lock gate.
R10	42565	04-16-73	4	DN	204	Wind swung light tow into shore structure.
R11	42249	03-19-74	10	DN	203	Outdraft topped tow around against dam.

MILE SEGMENT 200 (195-205)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R12	32082	04-30-72	UNK	DN	203	Outdraft topped tow against lock wall.
R13	60357	09-23-75	UNK	DN	197.5	Rounded bend out of shape. Hit barge.
R14	61733	01-12-76	9	UNK	203	Ice jam in lock - freeing caused damage.
R15	62178	02-18-76	UNK	DN	203	Waiting for lock - wind gust blew one tow into another.
R16	60957	11-24-75	UNK	DN	202.9	Misligned in lock. Hit wall. Windy.
C1	22123	03-14-72	10	UP	201	Misjudged stopping distance and collided with stern of towboat.
C2	32896	12-18-72	UNK	DN	204	Towboat assisting tow in ice, damaged barge.

MILE SEGMENT 270 (265-275)
UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	22382	05-10-72	4	DN	273	Failed to align with lock wall and hit lock wall.
R2	21568	07-02-71	9	DN	273.4	Failed to align with lock wall and hit gate leaf.
R3	52828	03-23-75	2	UP	273	Tow cable parted allowing barge to hit lock wall.
R4	50065	03-22-74	12	DN	273	Failed to align with lock wall - out draft rotated lead barge into lock wall.
R5	21957	03-09-72	2	UP	273	Tow rotated and hit dolphin in approach to lock.
R6	52555	05-18-75	15	UP	273.4	Did not stop in time; hit lock gate.
R7	31956	04-02-72	UNK	DN	273	Outdraft rotated tow into lock wall.
R8	32887	03-13-73	8	DN	273.4	Outdraft swung tow into lock wall.
R9	42714	05-02-74	13	DN	273.4	Outdraft topped tow out of lock on to dam.
R10	42675	04-13-74	4	DN	273	Outdraft swung tow into lock wall.

MILE SEGMENT 380 (375-385)
UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	31931	11-07-72	UNK	DN	384	Out of shape. Current forced tow into bridge.
R2	52939	06-02-75	UNK	DN	383.9	Outdraft forced tow into bridge.
R3	20347	07-12-71	15	DN	383.9	Outdraft forced tow into bridge.
R4	22175	04-27-72	12	DN	383.9	Current pushed head of tow into pier.
R5	42252	02-28-74	8	DN	383.9	Current set head of tow into bridge pier.
R6	31094	10-19-72	10	DN	383.9	Current set head of tow into bridge pier.
R7	32805	05-26-73	4	DN	383.9	Current set tow into bridge pier.
R8	32651	03-22-73	9	DN	383.9	Current set two into bridge pier.
R9	43336	06-30-74	12	DN	383.9	Current set tow into bridge pier.

MILE SEGMENT 380 (375-385)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R10	32652	05-24-73	8	DN	383.9	Overcompensated for cross current. Hit bridge.
R11	40001	06-03-73	12	DN	383.9	Current set tow into bridge pier.
R12	62352	03-20-76	8	DN	384	Current set tow into bridge pier.
G1	32087	03-09-73	3	UP	378.5	Grounded in high water. Unfamiliar with channel.

MILE SEGMENT 400 (395-405)
UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	20713	10-28-71	5	DN	403.1	Out of shape. Hit pier.
R2	22375	05-04-72	9	DN	403.1	Current set tow into pier.
R3	20659	10-11-71	2	DN	403.1	Wind and current set tow into pier.
R4	20985	11-23-71	2	DN	403.2	Current set tow into bank and bridge.
R5	50238	08-04-74	4	UP	403.1	Failure of steering system. Hit bridge.
R6	31095	11-18-72	UNK	UP	403.1	Current set tow into bridge.
R7	51001	06-18-74	5	DN	403.1	Current set tow into bridge.
R8	41240	11-19-73	2	DN	403.1	Rudder did not respond properly. Hit bridge.
R9	50237	07-27-74	3	DN	403.1	Rubbed concrete pier of bridge.
R10	43106	05-19-74	7	UP	403.1	Current set tow into bridge pier.

MILE SEGMENT 400 (395-405)

UPPER MISSISSIPPI RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R11	40270	07-07-73	9	DN	403.1	Current set tow into bridge pier.
R12	61967	03-08-76	UNK	DN	403.1	Current set tow into bridge pier.
G1	32806	06-20-73	15	UP	403.1	Hit submerged object under bridge.

CHART EXPLANATION SHEETS
OHIO RIVER

MILE SEGMENT 010 (005-015)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	50694	5-21-74	UNK	UP	13.3	Hit lock gate. Report stated tow did not back down soon enough. Operator stated lock master made him tie up on too long a lead allowing tow to slide into gate.
R2	31785	10-22-71	8	UP	6.2	While locking through, tow surged forward breaking lines and hit gate.
R3	50896	7-3-74	6	DN	13.3	Entered lock at slight angle. Lookout said shape O.K. Idling in on one engine.
R4	32916	6-9-73	3	UP	6.2	Entered lock at too high speed. Bumped gate.
R5	42950	6-7-74	UNK	UP	6.2	Tow surged within lock. First "cut" of barges in array.
R6	52010	3-9-75	6	DN	13.2	Making approach to Dashleld's lock, struck mooring cell. Barge sank.
R7	60245	5-6-75	4	DN	6.2	Stern started drifting away from wall. High water - strong current No lockman to assist.
R8	62808	1-1-76	UNK	UP	6.2	Strong outdraft. No lockman. Failure of facing wire holding array together allowed barges to hit middle lock wall. (Array longer than lock - would have to double it appears).

MILE SEGMENT 030 (025-035)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	60685	8-12-75	UNK	UP	31.7	Underestimated outdraft. Array hit center guide wall.
R2	60408	3-28-75	UNK	UP	31.7	Failed to stop forward motion. Tow operator says, "lockman failed to handle line properly".
R3	62824	10-21-75	UNK	UP	31.7	Failed to leave room for notch on tow, (2nd row of barges wider than lead row) Hit center lock wall.
R4	21173	2-11-74	11	UP	31.7	Radar approach Entered lock out of shape.
R5	50121	3-14-74	1	DN	31.7	Hit upper lock gate. Backed into closing gate while maneuvering in lock. No lines secured.
R6	41659	8-8-73	16	UP	31.7	Failed to stop in time. Hit upper gate. Excessive speed.
R7	42695	10-11-73	16	UP	34.7	Restricted visibility. Hit bridge pier. PIC thought radar showed crossing boat - made hard course change within 1/4 mi. of bridge. Unable to check swing. Apparently radar ghost or false signals. Recommended training and/or better electronics.
R8	30954	6-28-72	4	DN	34.7	Hit bridge. Swifter than normal current. Pilot failed to recognize greater "distance-to-stop" ratio because of current.

MILE SEGMENT 050 (045-055)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	50695	8-05-74	2	UP	54.4	Coupling between the two lead barges parted allowing the STBD lead barge to veer to STBD. Hit the guide wall of the New Cumberland lock. No damage to towboat.
R2	41456	9-13-73	4	UP	54.4	Reduced visibility - radar failure. Misjudgement of distance to lock by lookout.
G1	52667	5-17-75	UNK	DN	46.0	Struck submerged pipe embedded in end of guide wall/Old Lock 8.
G2	52303	1-12-75	8	UP	55.0±	Positioned vessel too close to shore while making approach to lock.
C1	62423	10-02-75	UNK	1 - UP 1 - DN	45.2	Collision in bend. Attempting "2" passing situation - agreement reached not successful passing. Radio contact before sighting attempted but not responded to. Sighted at 1/2-mile. <u>Note</u>: Both vehicles in "data base". Both operators cited.

MILE SEGMENT 280 (275-285)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	42508	4-01-74	8	UP	279.2	Proceeding into lock chamber at excessive speed. Check line broke - struck upper inside gate.
R2	62753	12-31-75	5	UP	279.2	Struck lock gate while locking. Did not correctly judge distance. Poor communications with lookout.
R3	61899	3-07-76			279.2	Lost power. Couldn't start. N.C.
R4	62445	3-02-76	6	UP	279.2	Misjudged foward motion. Barge hit landwall lock gate.
R5	32852 (32818)	6-03-73	UNK	UP	279.2	Failed to stop in time. Hit gate in lower approach. Same case as 32852. N.C.
R6	52257	2-08-75	4	DN	279.2	Excessive current set tow into wall. Current from port/land side.
R7	42518	3-02-74	5	UP	279.2	Failed to stop headway. Hit gate.

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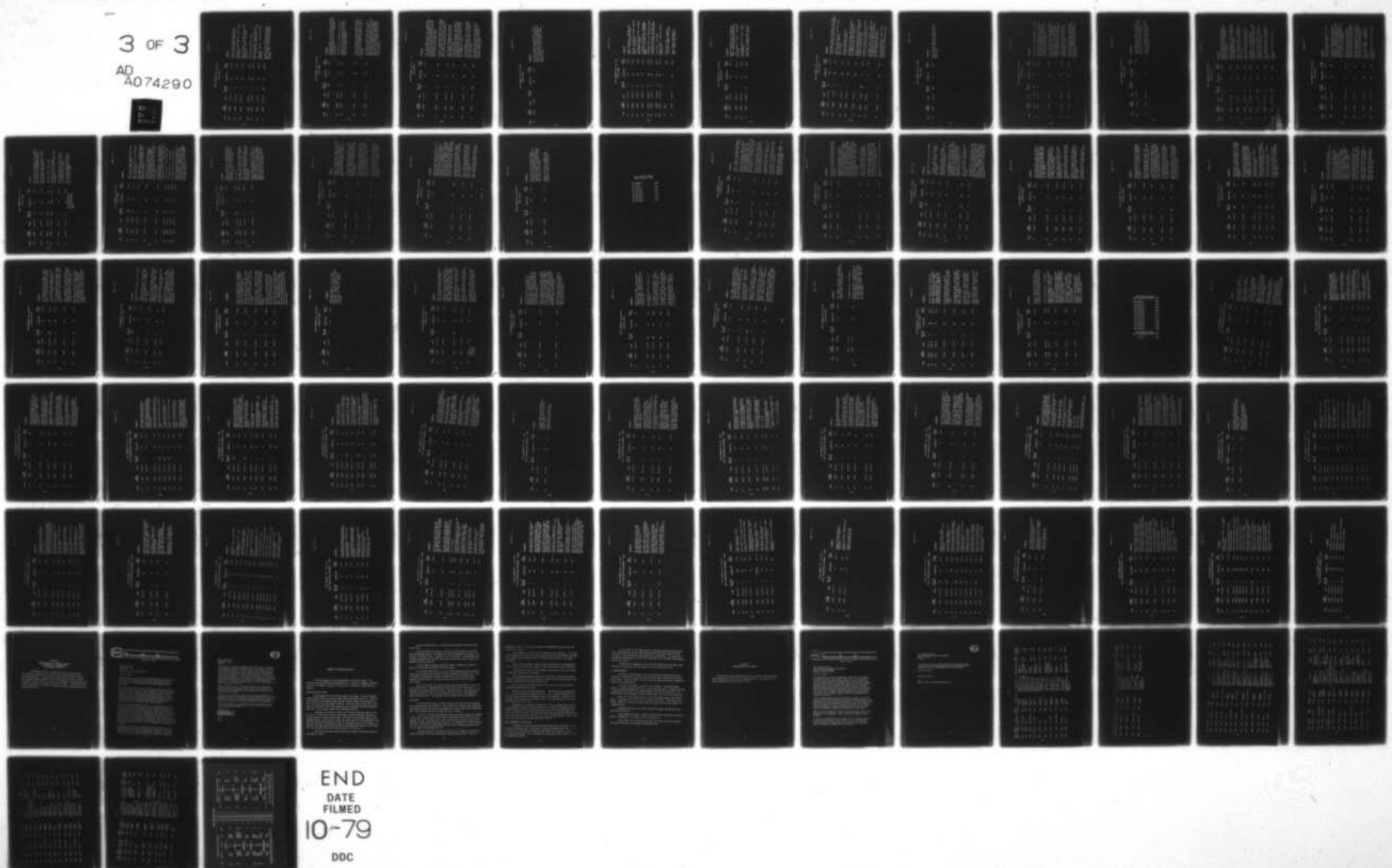

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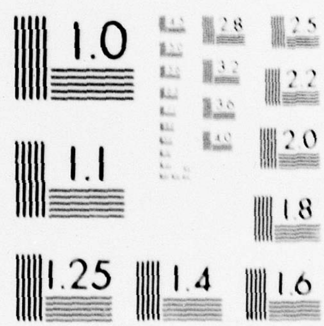
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MILE SEGMENT 280 (275-285)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R8	40996	5-16-73	11	UP	279.2	While in process of locking, hit river leaf of upper miter gate.
R9	41862	2-02-74	15	UP	279.2	Proceeding into chamber. Hit center guide wall.
R10	50418	8-06-74	2	UP	279.2	Double locking. Second cut of array struck gate recess. Misjudged current.
R11	43017	4-09-74	3	DN	278.7	Struck upper mooring cell.
R12	51964	1-07-75	4	DN	279.2	Excessive speed. Misalignment of tow. Struck land leaf of up er leaf.
R13	52449	4-26-75	8	DN	279.2	Misjudged current. Struck bullnose outdraft.
C1	31876	10-04-72	UNK	UP	280.7	Backing off the bank after having been aground. Misjudged distance to passing towboat who had permission to pass.

MILE SEGMENT 340 (335-345)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	61807	1-25-76	UNK	UP	341	Struck landwall leaf of upper lock gate. Misjudged distance due to communication problem between pilot and deckhand on lead barge.
R2	62866	6-18-76	6	UP	341	Outdraft set tow down on guide wall.
R3	30129	6-26-72	8	DN	341	Approaching lock guidewall pneumatic engine controls malfunctioned. Pilot could not reduce headway.
R4	21267	1-24-72	1	DN	341	Loss of control of main engines while in lock chamber caused barge to strike lower gate. (Starboard engine hung in forward. Port wheel had drift in port nozzle).
R5	20250	6-27-71	15	DN	341	Tow made up with notch while in lock notch struck wall, six lead barges broke away and struck upper miter gate. Coast Guard contended tow was poorly made up and towboat was underpowered (900 HP) for 12 loaded jumbo barges, a derrick boat, an empty barge, and a dead towboat.

MILE SEGMENT 340 (335-345)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R6	20382	7-21-71	8	UP	341	Fog - 100 yards visibility. Approached lock using both radar and lookout. Due to radar reflections guidewall not detected and by the time the lookout detected wall it was too late. Tow struck end of guide wall.
R7	42924	3-12-74	13	DN	341	In lock - misjudged current and forward motion. Struck river wall leaf of upper gate. Came down on wall prior to gate being fully open during high water.
R8	50645	1-31-75	8	UP	341	Had too much headway when entering lock chamber, subsequently struck upper lock gate.
R9	53211	2-28-75	4	DN	341	At approximately 200 feet upstream of lock. Strong wind (gusts) and strong outdraft set tow over across approach and caused tow to strike upper river wall breaking up tow.
R10	52261	4-27-75	12	DN	341	Strong outdraft set tow on long guidewall while entering locks. In shearing off also struck land wall and bank with lead barge.
C1	61160	6-15-75	UNK	UP	340	Collided with 25-foot motorboat which had broken down and was drifting in channel. Tow had just locked up through greenup locks.

MILE SEGMENT 340 (335-345)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
G1	21284	1-9-72	8	DN	344	2.5 mph current set tow over to left bank. Tow was 8 loaded oil barges with 14,189 long tons of cargo. 500 barrels of oil were lost. Coast Guard noted "marginal HP" of 1700. Visibility was only 1/2 mile.

MILE SEGMENT 600 (595-695)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	62011	2-24-76	6	DN	604.2	Strong outdraft. Extreme high water. Hit protection cell.
R2	62007	2-22-76	15	UP	604.5	Failed to allow for current leaving Canal. High water.
R3	21627	3-23-72	16	DN	603.4	Misjudged effect of wind, collided with moored vessel.
R4	21672	3-02-72	15	UP	603.5	Collision with bridge. Misjudged effect of outdraft from starboard shore.
R5	21527	3-12-72	12	DN	604.3	Misjudged wind, hit protection cell.
R6	21902	4-02-72	6	UP	607.0	Outdraft from lock. Hit wall at lock prior to entering lock proper.
R7	41970	11-26-73	9	DN	604.3	Cross wind. Out draft.
R8	52851	3-21-75	13	DN	602.9	Rammed bridge. Strong currents. High Water.
G1	61081				599.5	Barge took on water - operator purposefully grounded. (Not Coded)
G2	21292	2-07-72	8	UP	604.2	Came in contact with deposit of stone. Deposit later removed.

MILE SEGMENT 600 (595-695)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
G3	21899	3-19-72	9	DN	604.1	Couldn't ascertain if bridge was open. Trying to wait, lost control, array grounded and broke up.
G4	52463	3-03-75	6	DN	604.2	Cross current at point. Grounded at point.
G5	52260	6-01-74	6	DN	604.0	Overcompensated for cross current. Tow sheered.
C1	20551	10-02-71	12	UP	600.5	Collision with motor boat in fog - motor boat in middle of channel.

MILE SEGMENT 780 (775-785)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	50521	10-1-72	15	DN	777.7	Misjudged effect of outdraft. Hit bull-nose on guide wall. (Lock since removed.)
R2	50828	7-9-74	9	DN	777.7	Outdraft would not let tow go to the wall. Tow hit wickets. Light barges.
R3	52245	3-21-75	3	DN	776	Did not properly align tow. Strong wind. High water.
R4	50859	7-15-74	9	DN	777.7	Collided with closed gates and sector arm. Unaware that gate was closed. No communication with lookout.
R5	50397	8-30-74	3	DN	776	Nearby dam construction caused adverse currents. Strong outdraft - unable to properly align open river.
G1	60958	7-22-75	UNK	DN	776.3	Failed to allow for effect of current on tow when departing from lock.
G2	41361	8-25-73	7	UP	777.0	Misjudged width of channel. Buoys marking right side of channel missing (replaced 8-27-73) Heavy silting due to construction of new L/D. Had just departed lock/dam 47.
G3	40785	7-2-73	11	DN	776.5	Silting condition of channel due to construction of dam. Strong current to northwest bank.

MILE SEGMENT 780 (775-785)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
G4	52856	11-20-74	UNK	UP	778.5	Barge struck edge of large sand bar. Below L/D 47. Possibly built up by wheel wash.

MILE SEGMENT 810 (805-815)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	52853	11-04-74	UNK	DN	809.6	Head barge struck guidewall bullnose.
R2	62811	10-16-75	10	DN	809.6	Inoperative searchlight. Radar did not pick up remaining weir of dam. Attempted to navigate through navigable pass of old lock and dam. Collided with fixed weir.
R3	63108	10-07-75	7	UP	809.6	Fog - lost engines when attempting to go astern*. Hit old lock wall. Pilot's first trip. (*Engine's required delay to engage clutches - pilot reversed too fast and one engine had trouble being restarted.)
R4	60762	10-08-75	5	UP	809.6	Mistook red buoy for black buoy. Passed buoy on wrong side and ran into old fixed weir.
R5	51724	12-08-74	7	UP	809.6	Going through pass at old lock 48. Went over towards old lock on Indiana Bank to let downcoming tow pass through and hit submerged guide wall. High water.

MILE SEGMENT 810 (805-815)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R6	32518	3-03-73	5	UP	809.6	Zero visibility. Owner claimed buoy atop beartrap not picked up on radar - buoy was equipped with radar reflector. No lookout posted.
G1	32911	10-05-72	5	UP	811	While rounding bend in fog current apparent. Forced tow aground. Was in turn coming up on lock 48.

MILE SEGMENT 850 (845-855)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	52376	4-21-75	15	UP	846	Eddy and outdraft topped tow and struck lower wall (after approaching guide wall too fast. Stopped tow and was topped).
R2	41401	1-17-74	9	DN	846	Struck bullnose of river guide wall. Barge subsequently sunk. STBB flanking rudder was missing.
R3	51876	3-01-75	8	DN	846	Water at flood stage. Strong outdraft. Struck upper end of river guide wall.
R4	52553	4-16-75	2	UP	846	Strong eddy swung lead barge into wing wall or bullnose of lock.
R5	50862	3-03-74	15	UP	846	Wind gust - all light barges collided with "mooring cell" at lock. (Some kind of temporary structure.)
R6	52673	5-13-75	UNK	DN	846	Outdraft caused collision with bullnose of guide wall - one barge partially sunk ultimately.
R7	30669	9-06-72	16	UP	845	Eddy caused starboard lead barge to ride upon end of lower guidewall of lock.
R8	30839	10-02-72	UNK	UP	845	Lost main engine while making approach.

MILE SEGMENT 850 (845-855)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R9	31548	6-30-72	UNK	DN	845	Suction effect of current set tow into bear trap on dam.
R10	21368	11-26-71	4	DN	845	2 loaded barges carrying hazardous chemicals. STBD lead barge hit lock wall. Operator claimed rounded knuckle missing from guard rail caused damage - CG said operator failed to exercise "reasonable care" when entering lock chamber.
R11	21360	1-20-72	10	UP	846	Operator elected to go through opening between outer lock wall and dam under construction because locks were heavy with other traffic.
R12	21168	9-12-71	3	UP	845	Outdraft caused operator to back down and reapproach. On reapproach hit long wall of lock, lost port engine and then hit guide wall.
R13	31506	12-05-72	0	UNK	845	Small work towboat. Sucked into open gate in dam - subsequently sunk.
R14	22386	6-17-72	0	UP	845	Updraft below lock could not stop headway.

MILE SEGMENT 850 (845-855)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R15	22366	2-27-72	15	UP	846	Could not stop headway. CG contends using check lines between tow and lock would have prevented contact.
R16	22358	5-14-72	15	DN	845	Tow set over bear traps was passing across dam in high water.
G1	63161	6-14-76	UNK	UP	852	Unusually low river stage.
G2	62964	6-15-76	UNK	UNK	852	Unusually low river stage. Lock 50 pool had insufficient water. in channel.
G3	62813	6-15-76	4	UP	852.5	Pilot implied A to N off station. CG claimed that not prov. cause. (See previous two cases.)
C1	20041	3-19-71	12	UP (But in process of turning down-river coming off dock.)	851.5	Collided with downbound Barbara with 9 loaded barges off Island Creek Coal Co. dock.

MILE SEGMENT 940 (935-945)

OHIO RIVER

CODE	CODE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	60230	7-18-75	UNK	DN	938.9	Got out of shape approaching lock; hit center guide wall.
R2	60837	3-18-76	14	DN	937.3	Wind off port blew tow into bridge pier high water.
R3	62627	6-14-76	12	UP	938.9	Misjudged speed - hit outside guide wall. MT's in front damaged. Wind blowing on starboard purposefully aligned outside.
R4	63292	7-25-76	13	DN	938.9	Towboat hit lock approach wall at right descending bank. Misagreement in information from lookout as operator could not see lock due to night. Recommended that lock wall be lighted.
R5	40240	6-16-73	UNK	UP	938.9	Flood conditions. Tow cleared lock, unusually strong cross wind forced tow of MT barges toward chamber - hit check pin on top of lower guide wall.
R6	42512	1-18-74	25	DN	937.5	Strong current. Flood conditions.
R7	41888	2-05-74	7	DN	937.3	Misjudged current. High water.
R8	51826	1-21-75	14	DN	940.8	Misjudged strong set of current.
R9	42464	4-25-74	27	UP	938.9	Open river conditions. Passing starboard/starboard, crowded by other array, moved to outside wall, red light was out on lower wall, thought light seen was lower, but was upper. Hit lower. (Light out for 6 weeks.) Wall submerged 3'-0".

MILE SEGMENT 940 (935-945)

OHIO RIVER

CODE	CODE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R10	40942	10-28-72	15	DN	940.8	Bridge construction machinery main channel span had to use narrow span. High water. Strong current set to starboard. L&D 52 running two traps w/815 at dam down. Hit bridge.
R11	31550	10-28-72	UNK	DN	940.8	Same as R10.
G1	60779	5-18-75	2	DN	938.9	Dam open. Went over bear trap, but insufficient water to clear bottom.
G2	60028	7-18-75	2	DN	941.5	Lock operator advised buoy off station; tow took buoy on wrong side. Went aground. Low water conditions contributed.
G3	50925	10-31-74	11	DN	938.8	Cross winds gusting to 25 mph. 3 barges had freeboard and above deck bulwark height of 25 feet. Sail effect. Preparing to lock through wind pushed array to STBD correcting steered to port putting stern to STBD. Operator had only 4 months experience in these waters.

MILE SEGMENT 980 (975-985)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	61156	1-10-76	0	UNK	980.5	Making up tow burned boat loose from barges to drop down to make up tow and backed down into bridge pier. Wind was blowing exhaust smoke toward stern obscuring visibility aft.
R2	50033	6-13-74	19	DN	978	Going through ICRR bridge with M/V Richard C. Young faced up at head of tow. Tow set toward Illinois shore laid against Dolphin at Bungee Grain dock.
R3	32712	2-08-73	7	DN	980.5	While navigating through Cairo Hwy Bridge strong side draft caused by flood stage caused barge to collide with right descending bridge fender. Visibility was one mile and wind gusting to 15 KTS.
R4	52551	2-06-75	24	DN	977.7	Flanking through ICRR Bridge, one barge made contact with bridge pier. Ruptured barge wing tank. Barge ultimately sank. High water conditions.

MILE SEGMENT 980 (975-985)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R5	22115	12-16-71	2	DN	980.5	Heading toward lower fleet area to make up tow. Fog rolled in. Thought another tow was coming up-river which was actually stopped. Operator then stopped his tow. Current set tow crosswise. Visually sighted other tow, which ultimately came through span, and to avoid collision went ahead and turned and struck bridge pier (Cairo Hwy Bridge)
R6	51683	1-23-75	11	DN	980.5	Passing through Cairo Hwy Bridge set down and collided with bridge. Five barges broke away. Visibility was 1/2 mile.
R7	42513	3-31-74	25	DN	977.7	While approaching ICCR Bridge tow got out of shape and struck bridge pier. High currents due to high water present.
R8	51414	1-05-75	15	DN	977.7	While navigating bridge span starboard lead barge struck bridge pier.

MILE SEGMENT 980 (975-985)

OHIO RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R9	52249	2-06-75	14	DN	977.7	Lining up tow with ICCR Bridge. High water, high current caused tow to shear when operator tried to realign tow face. Wires parted and tow drifted down on bridge. Winds were gusting to 20 MPH.
C1	62009	4-06-76	1	UNK	977	Towboat was putting barge into another's tow and collided with headlog of barge in that tow.

CHART EXPLANATION SHEETS
LOWER MISSISSIPPI RIVER

MILE SEGMENT 40 (35-45)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	62945	4-27-76	UNK	DN	43.2	While passing through RR Bridge span, current set tow into bridge.
R2	62236	3-14-76	15	DN	43.2	Flanking through bridge, current set tow into bridge protection partially breaking up tow. As operator attempted to back out, current caused after portion of tow to top around crosswise into right descending pier. Ice was present.
R3	62654	11-12-75	UNK	DN	43.2	While transiting RR bridge, tow became misaligned due to current and made contact with bridge pier. Visibility was one mile.
R4	60338	8-23-75	3	DN	43.2	Misalignment and beam wind on light barges set tow onto bridge pier.
R5	61157	1-05-76	UNK	UP	43.2	Tow struck left descending end of shear fence. Wind and current contributed to accident.
R6	61015	11-14-75	15	DN	43.2	Navigating through span, barge struck turntable fender works. Tow misaligned for passage.

MILE SEGMENT 40 (35-45)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R7	62365	5-20-76	UNK	UP	43.2	Current and missing lower protection fence on bridge pivot caused tow to hit pier.
R8	64104	6-30-76	15	DN	43.2	Tow struck underwater concrete ledge of bridge pier, which is normally protected by fender works which were being repaired. Normal water depth would allow safe passage over ledge, but low water conditions precluded such. After striking ledge, tow sheered and struck center pier fenderworks. Was being assisted by another towboat, "ELCO", during passage.
R9	52826	6-03-75	15	UP	43.2	115-ft. wide tow going through 121-ft. bridge span in current at night struck bridge fenderworks.
R10	21905	2-17-72	2	UP	43.2	Tow did not respond quickly enough to STBD rudder and/or operator did not apply sufficient rudder in time to make turn in exiting from bridge span. Tow struck bridge pier.
R11	32727	11-18-72	2	DN	43.2	Strong current swept tow into fenderworks.

MILE SEGMENT 40 (35-45)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R12	32880	3-12-73	UNK	DN	43.2	River current set tow into shear fence.
R13	50597	6-07-74	2	DN	43.2	"Stronger than normal outdraft" around bridge set tow. Current was 8 mph.
R14	32890	2-25-72	UNK	DN	43.2	High water causing excessive currents was unable to control tow and hit bridge pilings.
G1	60202	6-16-75	9	DN	43.4	In attempting to line up tow for bridge passage at mile point 43.2 downstream, tow ran aground. Barge array was 3-wide (approximately 100 - 110 ft.) and had bow boat assisting. At time wind was on beam of tow at 20 kts.
G2	51104	3-28-75	UNK	DN	36.0	Due to high water conditions operator lost control and tow ran aground.
G3	42743	3-13-74	13	DN	43.3	"Unpredictable current action" upon towboat's stern and caused tow to top around to a position where operator "was unable to back out of danger." Subsequent grounding and tow break-up swamped the M/V JAMES TAYLOR which was on towboat's port hip in addition to 12 barges being pushed.

MILE SEGMENT 160 (165-155)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	21606	6-10-72	9	DN	162.3	Tow struck sheer fence protection works between Franklin St. Hwy Bridge and TP & W RR Bridge. Tow partially broke up and Barge AD-3 drifted downstream striking Cedar St. Hwy Bridge.
R2	21904	2-28-72	12	UP	162.3	Proceeding through Franklin St. Bridge against a large amount of floating ice, caused tow to shift striking bridge piling.
R3	21956	3-22-72	7	UP	160.7	Did not align tow prior to bridge passage and struck bridge pier protection cell.
R4	20850	8-22-71	12	UP	162.3	Improper alignment caused striking of bridge pier protection cell with tow.
R5	51882	3-02-75	4	DN	162.3	Improper alignment caused tow to sheer and strike old RR bridge pier after passing through Franklin St. Hwy Bridge.
R6	51747	2-01-75	4	DN	162.3	Misjudged approach angle due to current and hit bridge fender works.

MILE SEGMENT 160 (155-165)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R7	51313	12-06-74	3	DN	157.8	Going through Peoria lock, crosswind set head of tow, striking upper end of lock wall - visibility 1/2-mile in rain.
R8	41259	6-14-73	1	DN	159.9	Moving derrick barge under high tension transmission line - misjudged height, struck and severed line.
R9	40344	2-05-73	4	DN	160.7	P & PU Bridge had been damaged with jagged steel protruding into channel from left descending pier span, when trying to avoid previously damaged right descending pier span.
R10	40004	5-02-73	4	DN	162.3	In attempting to avoid hitting pier of old RR bridge just below Franklin St. Hwy Bridge, hit upper dolphin of Franklin Bridge.
R11	61099	10-30-75	UNK	DN	160.7	Navigating through P & P& RR Bridge. Made contact with work flat protruding into channel due to "misalignment" according to CG.

MILE SEGMENT 160 (155-165)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R12	61965	3-11-76	UNK	DN	162.3	High water - strong current, coupled with 22 mph wind set tow on to right descending cell of Franklin St. Hwy Bridge.
R13	61377	11-25-75	UNK	UP	162.3	While navigating through Franklin St. Hwy Bridge, wind set tow down on bridge - also had main engine problems during course of events. Visibility 1 mile in rain.
R14	61287	11-29-75	4	DN	162.3	Misaligned tow struck Illinois Terminal RR Bridge.
R15	60441	3-05-75	UNK	DN	162.3	Angle of approach was misaligned and speed was excessive - subsequently collided with bridge pier.
R16	63620	7-04-76	UNK	DN	160.2	Transiting P & PU Bridge, current set tow on bridge pier.
R17	63370	6-30-76	UNK	UP	162.7	After clearing Franklin St. Hwy Bridge, did not clear subsequent Murray Baker Bridge, striking water intake pier.

MILE SEGMENT 160 (155-165)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R18	60022	5-19-75	UNK	UNK	162.3	Could not stop swing of tow. Collided with Peoria-RR Bridge pier.
R19	62097	3-24-76	UNK	DN	160.7	Signalled P & PU Bridge to open and continued slowly downstream, anticipating bridge to open. About two tow lengths upriver realized bridge was not going to open and began backing. Struck bridge in closed position, operator failed to recognize flashing red lights on bridge as signal that bridge was unable to open.
R20	62070	1-29-76	UNK	DN	162.3	In attempting passage through old Illinois Terminal RR Bridge, lost control of tow due to heavy ice and struck left descending bridge pier.
R21	62709	4-11-76	UNK	DN	162.3	Coming through Franklin St. Hwy Bridge, current set tow to STBD into fender system of TP & W Bridge.
R22	61017	10-06-75	UNK	DN	158.0	Making approach to Peoria Lock, current set tow into I-474 Highway Bridge protection cell.

MILE SEGMENT 210 (205-215)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	63743	7-27-76	9	DN	213.9	Tow misaligned with bridge. Could not stop tow before ramming shear fence. Bridge possibly in repair.
R2	61041	11-08-75	UNK	UP	213.9	Out of shape for bridge coming out of bend. Scraped bridge pier.
R3	43384	1-25-74	9	DN	213.9	Out of alignment under bridge, tried to straighten out by backing, unable to because of following current and wind.
R4	20854	8-14-71	5	UP	213.9	Out of shape due to bank suction in shallow water. Backed to kill headway and alignment - unable to kill headway and hit turntable pier.
R5	41825	6-21-73	10	DN	213.9	Tow had to come to "drift" to wait for bridge to open - bridge operator waiting to ascertain status of approaching train. By time bridge opened, tow had lost headway and was unable to get tow under control.

MILE SEGMENT 210 (205-215)
ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R6	30881	7-27-72	UNK	DN	213.9	Not aligned properly. Hit landside pier.
R7	30024	4-27-72	2	UP	213.9	Bridge was not open. Attempted to land on "protection" to await opening, was unable to kill headway. Hit bridge.
R8	53067	1-15-72	9	DN	213.9	While transiting bridge, sudden set caused by bridge and bend in river. Caused tow to sheer to STBD. Tow at dead slow speed.
G1	51009	6-12-74	4	DN	210	Misjudged effects of strong current while river in flooded state.
C1	53061	1-18-75	4	DN	210.2	Collision on bend in river. Bend channel not wide enough for parallel passing - towboat holding up for upbound tow after reaching agreement. Wind (30 k) blew barge array into upbound tow.

MILE SEGMENT 240 (235-245)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	50533	7-24-74	3	UP	239.3	Effect of current after navigating a bend and maneuvering to transit narrow lift bridge opening.
R2	50837	6-13-74	8	DN	244.6	Leaving mooring to enter lock could not get into shape. Current put tow array into lock wall. 2nd time on river.
R3	50394	6-26-74	5	DN	239.3	Hit sheer fence. Current set under narrow lift bridge, forced tow into sheer fence. Front of tow through bridge.
G1	63800	9-26-76	15	UP	244.8	Grounded. Low water conditions. May have been too close to bank, given the low water condition.
G2	61616	3-09-76	2	DN	244	Grounded on port bank after leaving lock. Strong merging current on STBD. Towboats awaiting lockage upstream reduced maneuvering space-could not hug STBD side due to tug moored there.

MILE SEGMENT 240 (235-240)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C1	53058	3-13-75	4	UP	243.2	Awaiting lockage. Did not leave sufficient room for vessel to pass downriver. Vessel coming out of lock could not pass and vessels collided.

MILE SEGMENT 270 (265-275)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	22026	3-20-72	4	UP	269.9	Port steering rudder malfunctioned. Tow collided with moored barge.
R2	53076	6-08-75	4	DN	271.5	Working into lock, tow became misaligned. Came up against protection piers and veered to left. Barge made contact with lock gate. Fumes from holed cargo tank were ignited.
R3	31571	11-19-72	Unk	DN	271.5	Approached mooring piers above locks at night too fast. Collided with mooring piers.
R4	43153	3-07-74	7	DN	270.5	Tow set to STBD while negotiating RR bridge span and struck protective pier.
R5	33060 (43155 is identical to 33060)	1-03-73	6	DN	270.5	In snowstorm at night with 1/2 mile visibility and 30 knot winds, tow was set into protective piers of RR bridge.

MILE SEGMENT 270 (265-275)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R6	63504	9-03-76	2	UP	269.9	Due to low water, tow took run across river. Steerageway in shallow water could not be maintained and tow veered to right descending bank. Operator attempted to back down to straighten tow but struck moored barge.
G1	51034	10-18-74	4	DN	274.4	Bank suction pulled towboat toward right descending bank while making turn to STBD. Stopped STBD engine which took lift off rudder. Head of tow subsequently swung left and ran aground on left descending bank. Two daymarks just downriver (one Bonnell light) were missing.
G2	21262	12-25-71	4	UP	274.0	Visibility was 1/4-mile in fog at night. Operator was attempting to hold up and in getting out of channel struck bottom.

MILE SEGMENT 290(285-295)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	53075	5-08-75	4	DN	293	High wind off port. Other barges tied to bank. Trying to clear butterfly dam. Stern rubbed barges on bank causing bow to hit protective cell.
R2	61165	12-30-75	UNK	DN	293	Misjudged distance to canal wall - 80' channel.
R3	60840	8-09-75	UNK	DN	288.1	Hit bridge. Bridge operator did not raise bridge promptly. Tow did not have time to back and stop.
R4	63237	3-28-76	UNK	UP	287.1	Hit moored barges on right descending bank. Out of shape after having come through bridge. No lookout.
R5	62482	9-29-75	13	UP	287.8	Array struck sailboat moored on right descending bank. Could not see sailboat because of height of light barges.

MILE SEGMENT 290 (285-295)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R6	62478	4-09-76	14	UP	287.3	Hit bridge. Operator failed to have enough maneuvering room after transferring barge to a fleeting tug. Just getting underway - couldn't make the steer or stop.
R7	63509	5-10-76	6	DN	293.5	Hit moored bridge. Strong wind. Restricted channel width due to moored barges.
R8	33078	5-12-73	UNK	DN	291.2	Struck moored sailboat - Sailboat moored in restricted area. Approaching locks. Bend obscured view.
R9	43352	2-24-74	8	UP	288.3	Struck moored tow array - 100' wide. Failed to properly judge distance between canal wall and moored array. Strong current. Strong wind.
R10	43357	9-08-73	6	DN	288.7	Hit bridge span. Bridge tender signal that bridge would be opened. Could not get bridge to open. Warning too late for tow to back down.

MILE SEGMENT 290 (285-295)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R11	43388	3-07-74	4	DN	288.1	Hit bridge. Failed to compensate for bow cushion effect after passing moored array. Tow sheered.
	33073	3-16-73				Incomplete case. No towboat.
C1	53060	1-17-75	3	UP	287	Head on collision. Lights and snow hindered vision. Fleeting area. Two tows making up tows in vicinity. No radio contact until sight - 300 ft. No lookout posted. Had just cleared bridge.

MILE SEGMENT 300 (295-305)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	63742	7-03-76	4	UP	303.0	Struck moored barge. Dense fog.
R2	43066	1-20-73	2	DN	301.0	Struck moored barge. Did not see barge. Background shore lights.
R3	51087	1-29-74	4	UP	300.0	Struck towboard making up array. Limited visibility. Channel restricted by tow being made up.
R5	62728	3-09-76	2	DN	296.0	Struck moored barges. Moored barges cocked into channel. Bright lights from power station obscured vision.
R6	33077	4-22-73	5	DN	299.0	Struck moored barge. Three miles of barges moored on left descending bank. Hit barge moored outboard of string of barges.
R7	61571	2-24-76	10	DN	299.0	Hit canal wall. Failed to compensate for 15 kt. wind. Holding tight to wall to avoid tow making up in channel.
R8	43386	1-01-74	5	DN	299.0	Struck moored barge which was sticking out into channel because of broken mooring line. Fog. Strong wind.

MILE SEGMENT 300 (295-305)

ILLINOIS RIVER

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R9	53056	2-23-75	4	DN	300.5	Struck construction crane under bridge. Tow having difficulty maneuvering because of strong wind and insufficient horsepower (600 h.p.).
C1	50746	8-17-74	1	DN	302.8	Hit drifting barge - unlighted.
C2	33056	6-08-73	5	UP	302.5	Failed to check tow after reaching passing agreement. Tow was to remain stationary until other vessel passed.
C3	53066	1-23-74	4	DN	304.0	Collided with upbound vessel when port engine failed and vessel sheared. Other vessel stationary for passing. Passing agreement reached. Additionaly barge moored reduced channel width.
C4	49989	3-01-74	1	UP	299.0	Collided head on. Agreement to pass reached. Failed to give other vessel enough room in restricted channel. Other vessel riding the wall.
C5	53055	1-03-75	8	UP	396.3	Collision with passing vessel. Failed to give enough way for passing. Passing agreement reached. Channel restricted because of moored barges.

CHART EXPLANATION SHEETS
GULF INTRACOASTAL WATERWAY (WEST)

CHART EXPLANATION SHEET
GULF INTRACOASTAL WATERWAY (EAST)

MILE SEGMENT 010 (005-015)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	40491	04-19-73	6	UP	10.5	Pilot error in judgment around slight bend. Struck moored barge.
R2	21321	12-16-71	3	UP	12.5	Master misjudged gusting wind's effect on light tow passing bridge.
R3	20943	12-03-71	2	UP	12.5	Tow was too close to bank; the suction was maneuvered out of, but barge bounced into fender system.
R4	20838	10-25-71	4	UP	12.5	Operator lost control of tow because of current and brushed fender system; then the other side of the bridge was hit when coupling broke.
R5	62256	1-24-76	5	UP	12.5	Swinging part of bridge was protruding into channel. Wind pushed barge into it.
R6	62269	10-23-75	1	DN	12.5	Tug pulling, tow pushing 74' wide barge through 75' bridge. Operator of lead tug misjudged current and wind effect on tow, hitting fender works

MILE SEGMENT 010 (005-015)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R7	41078	11-22-72	4	UP	12.5	Bridge was partially closed because of previous accident. Tow had to avoid dredge and other tow located near bridge. Wind blew light tow into bridge.
R8	41322	12-02-73	4	UP	14	Coupling line broke causing barges to hit moored motorboats and dock.
R9	50045	03-14-73	2	[illegible]	10	Tow operator didn't detect moored barge in time to avoid it.
G1	22164	03-16-72	1	UP	15.2	Tow/barge was forced out of channel by other downriver tow; to avoid collision tow grounded.
C1	41689	09-20-73	5	DN	14.5	Operators failed to make passing agreement.
C2	41995	07-09-73	2	UP	11	Collision in narrow channel on a bend. Cause unknown.
C3	42851	04-25-74	3	DN	14.5	Two tows meeting in blind bend unaware of each other.

MILE SEGMENT 050 (045 -055)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	21801	12-22-71	2	UP	49	Foggy conditions at night. One tow was stopped on side of channel in a bend; other tow was coming to bend, called ahead for traffic, no answer, hit stopped tow.
R2	51461	10-07-74	4	UP	49.7	Bridge tender did not hear tug blow to open bridge and tug operator misjudged stopping distance for unopened bridge.
G1	32127	03-01-73	3	UNK	52	Operator misjudged current while rounding slight bend? with 3 barges in tow.
C1	20146	06-29-71	3	DN	52	Tug with three barges collided with another tow. Tug not sufficient for tow, could not control tow it was pulling in a meeting situation.
C2	60212	12-07-74	2	DN	53	Bank suction caused downriver tow to sheer across channel into upriver tow.
C3	61443	06-23-75	1	UP	53	Meeting tows did not communicate. One tow did not have lookout, other tow's radar was not working properly.

MILE SEGMENT 060 (055 - 065)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	62662	04-06-76	1	UP	60.0	Starboard rudder was missing. Tow rammed moored vessels.
R2	60200	02-04-75	1	DN	58.9	Tow making bend just ahead of bridge. Inexperienced operator could not make the turn through the bridge.
R3	61000	03-05-75	3	UP	57.6	Tow operator misjudged wind's effect on light tow & hit bridge.
R4	42199	11-20-73	UNK	DN	57.6	Bridge malfunctioning, wouldn't open.
R5	41025	06-11-73	UNK	UP	59.7	Tow operator misjudged strong current and hit bridge.
R6	42448	03-19-74	UNK	UP	59.7	Bridge malfunctioning, wouldn't open.
R7	50354	02-02-74	4	UP	59.7	Operator misjudged effect of wind & current while passing bridge.
R8	41158	05-13-74	3	DN	59.5	Operator misjudged effect of current at junction of GIWW & Houma Canal, hitting moored barge. Barge was on south bank in a bend.

MILE SEGMENT 060 (055 - 065)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R9	20275	07-27-71	UNK	UP	60.0	Operator navigated too close to bank allowing suction to sheer vessel into moored barge.
R10	21897	04-06-72	3	UP	60.0	Tow collided with moored barge while trying to avoid tug which was attempting to rescue the barge.
R11	32029	01-26-73	UNK	DN	58.9	Towboat operator was unable to control tow going through bridge.
R12	21076	10-08-71	4	UNK	57.6	Current affected tow going through bridge.
R13	20039	01-21-71	3	DN	58.9	Tow was approaching bridge. Developed generator trouble, then steering was lost.
R14	30440	08-13-72	2	UP	58.9	Tow making bend, started to slide. Operator couldn't get it under control before reaching bridge.
R15	21948	02-14-72	4	UNK	59.7	Tow operator used fender of bridge as pivot point to turn tow.
R16	20843	11-03-71	1	DN	57.6	Tow was too close to one side of channel going through bridge.

MILE SEGMENT 060 (055 - 065)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R17	21949	03-28-72	2	DN	57.6	Towboat pulling tow on slack line hit bridge.
R18	21890	01-23-72	4	DN	56	Tow proceeding at immoderate speed in fog; hit moored barge.
R19	62213	12-05-75	UNK	DN	59.7	Unlit dolphin of bridge under construction was hit by tow.
R20	41434	08-15-73	1	DN	57.6	Tow carrying deck cargo failed to line up tow going through bridge. Cargo hit girder.
R21	63919	06-20-75	UNK	UP	57.6	Tow wasn't lined up correctly going through bridge.
R22	63402	05-28-75	1	UP	57.6	Tow operator was asking directions from crew members to guide him through bridge and failed to align his tow with bridge opening.
G1	62264	08-03-75	2	UP	60	Steering system failure.
G2	32341	05-12-73	UNK	DN	59.9	Tow operator was unable to control tow in a bend. Tow grounded.

MILE SEGMENT 060 (055 - 065)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C1	50355	06-21-74	2	DN	63.5	Two tows failed to communicate. First tow operator was unable to check the swing of his tow rounding bend in meeting situation.
C2	31523	07-06-72	5	DN	63.7	Meeting tows, rounding bend. One tow crossed center line.
C3	52398	01-05-75	3	DN	56.6	Meeting tows, rounding a bend. One tow was too close to bank; the suction caused tow to sheer into other tow.
C4	40075	12-28-72	2	UP	59	Meeting tows communicated. Suction caused one tow to sheer into other tow.
C5	22154	04-14-72	3	UP	60.2	Both tows failed to keep to their side of channel rounding a bend in a meeting situation.
C6	21113	11-01-71	1	UP	60	Two tows rounding bend in meeting situation, no communication. One tow was unable to maintain control probably due to manner of towing (astern).

MILE SEGMENT 060 (055 - 065)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C7	20286	06-09-71	3	UP	64	Two tows meeting in straight channel. One tow got too close to bank resulting in suction and collision.
C8	32417	12-06-72	3	UP	60	Tows meeting in bend. One crossed its side of channel.

MILE SEGMENT 090 (085 - 095)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	32270	01-22-73	3	DN	94.3	At intersection of channel with other waterway, tow was avoiding another moving vessel and loose barges. Tow hit piling on side of channel.
R2	52193	04-11-75	3	DN	94	Current at ICW/Bayou Shaffer intersection pushed tow into steel piling on N. bank. (Had grounded at mi. 95.5 after rounding bend at Atchafalaya/ICW.)
R3	63349	03-27-76	2	UP	93.1	Tow approaching lock guide wall in low visibility and gusting winds. Hit guide wall.
R4	42281	06-03-73	5	DN	91.7	Rammed tow stopped in bend, westbound. Eastbound tow had to maneuver around tows stopped waiting to enter lock on both sides of channel, but hit tow stopped in bend.
R5	32121	01-24-73	2	UP	94.8	Moored Army survey boat was hit by tow which had stopped to allow another tow to pass. Current caused lead barge to swing.

MILE SEGMENT 090 (085 - 095)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R6	20604	10-13-71	1	DN	92.0	Eastbound tow hit barge moored in bend (probably barge lights were inadequate) at night.
R7	32287	02-15-73	2	DN	94.8	Eastbound tow misjudged effect of current, hitting moored barge on other side of channel.
R8	40084	04-05-73	4	DN	94	Tow misjudged current at intersection of bayou & ICW, striking moored ferry on other side of channel.
R9	40067	05-27-73	2	DN	94.4	Strong current caused operator to lose control, striking moored barge on other side of channel.
R10	32322	01-22-73	2	DN	94.3	Same as above.
R11	32561	01-22-73	1	DN	94.3	Due to strong current, tow hit piling then rammed other tow which was stopped.
R12	43284	12-15-73	3	DN	95	Tow passing dredge's pontoon line in dense fog. Damaged line.
R13	31129	10-05-72	3	UP	92	Tow hit pilings, went over bulkhead fill and hit trailer.

MILE SEGMENT 090 (085 - 095)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C1	42849	09-23-73	3	DN	87.5	Two tows meeting in sharp bend. They brushed each other while passing.
C2	30975	03-12-72	3	DN	94	Two tows meeting. One tow lost control due to strong current, hitting the other tow head-to-head.
C3	40921	08-09-73	2	UP	87.2	Two tows approaching sharp bend. Late detection on part of both, resulting in head-on collision.
C4	32958	04-24-73	2	DN	94	Two tows in meeting situation were unable to contact each other on Ch. 16 because of its being used a lot. One tow lost control in an eddy current, striking other tow.
C5	21932	01-02-72	4	DN	94	Tow was stopped. Cross-currents moved it into path of oncoming tow.
C6	41685	06-28-73	3	UP	94.3	Tow was affected by adverse current at intersection of two bayous causing it to fall toward oncoming tow.

MILE SEGMENT 100 (095 -105)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	32750	05-07-73	1	UP	98.2	One tow was grounded on North bank due to effect of strong cross current at Atchafalaya/ICW crossing. Second tow making same turn was affected similarly and rammed grounded tow.
R2	32708	04-23-73	7	UP	98	Upriver tow was stopped, waiting to turn into ICW whenever lock master indicated. Traffic was clear. Downriver tow was making bend, rudder got stuck and current turned it around into stopped tow.
R3	41588	06-20-73	2	DN	95.4	One tow hit sand bar and grounded. Another tow travelling in same direction hit same uncharted sand bar, rammed grounded tow and became grounded also.
R4	43270	03-14-74	2	UP	95.9	Tow was aground on north bank. Tow on same side of channel broke "port stern facing wire" causing barge to ram grounded tow.

MILE SEGMENT 100 (095 - 105)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R5	21112	12-11-76	4	DN	104	One tow was passing another tow stopped on bank on its starboard side. A coupling broke on the moving tow causing the lead barge to ram the stopped tow.
R6	62503	10-03-75	3	DN	95.4	Tow making bend. Current plus lack of enough horsepower pushed tow into dock.
R7	21964	03-19-72	1	DN	95.4	Tow was making bend. Strong current pushed tow into dock.
R8	32323	10-28-72	2	UP	99	Tow was affected by bank suction; hit moored barge.
G1	32534	03-02-73	2	UP	98.2	Tow was making bend. Operator misjudged current resulting in grounding.
G2	32598	04-21-73	5	UP	98.2	Same as above
G3	52339	01-30-75	2	UP	98.2	Same as above.
G4	20168	03-22-71	4	DN	95.4	Tow was making bend. Strong current pushed tow onto south bank.

MILE SEGMENT 100 (095 -105)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
G5	32633	05-05-73	2	UP	99	Tow was avoiding collision with approaching vessel in dense fog when it ran aground.
C1	32416	12-23-72	4	DN	98.1	Two tows meeting at intersection of ICW & Atchafalaya. Eastbound tow operator couldn't control it due to adverse current. Result was head-on collision.
C2	32662	12-28-72	4	DN	95.4	Two tows meeting at blind bend. Eastbound tow couldn't control his empty barges, crossed center line, hitting other tow.
C3	42072	07-04-73	2	UP	104	One tow had grounded on a shoaling area and was attempting to free itself. It drifted across the channel into an incoming tow.
C4	61795	11-22-75	6	DN	100	Tow was taking a bend. Shallow water reduced operator's ability to control tow and tow hit oncoming tow.
C5	21081	07-30-71	4	UP	98.4	Tow was making bend. Current pushed tow into oncoming tow.

MILE SEGMENT 100 (095 - 105)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C6	21388	01-12-72	2	DN	98	Tow operator didn't realize that he was overtaking tow ahead of him, hitting the stern of the overtaken tow.
C7	61794	12-23-75	3	UP	104	Tows meeting. The couplings broke on one tow, swinging the barge into path of approaching tow.

MILE SEGMENT 110 (105-115)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	60211	05-01-75	2	UP	113	Brushed bridge fender system due to wind.
R2	62457	08-03-75	2	DN	107.5	Underpowered tow rammed dredge.
R3	41557	11-14-73	3	UP	113	Bridge failed to raise. Vessel rammed bridge.
R4	20027	03-29-71	4	UP	113	Wind pushed 4 light barges into bridge fender system.
R5	50482	07-21-74	2	DOCKING	112.5 (?)	Current pushed tow into dock.
R6	21555	02-16-72	4	UNK	113	Bridgetender failed to raise bridge.
R7	52630	04-06-75	4	DN	107.7	Coupling wire broke causing tow to break apart and ram itself.
R8	42545	01-29-74	1	UP	111	Suction while passing close to barge/tow sucked vessel into other.
C1	63301	04-19-76	2	UP	107.7	Unlicensed helmsman failed to keep to starboard.
C2	32465	11-03-72	3	UP	111	Tow failed to signal in bend; failed to keep to side of channel.
C3	63875	06-17-76	3	UP	113.5	Suction effects caused tow to swing into oncoming derrick.

MILE SEGMENT 120 (115-125)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C3	50886	07-10-74	4	DN	122.5	Tows meeting, with agreement. One tow grounded, swung into other tow.
C4	21352	12-22-71	4	DN	120.2	Tows in meeting situation agree on passing. One tow has steering problem, other tow stops to allow him to go by but is hit anyway.
C5	40169	01-18-73	5	DN	120	Tows meeting in sharp bend, one was affected by current.
C6	20176	07-20-71	3	DN	121.2	Two tows rounding bend unaware of each other.
C7	20204	07-27-71	3	UP	120	Two very long tows not sure of each others exact location, making bend.
C8	20375	08-28-71	3	DN	121.2	Two tows rounding bend unaware of each other.
C9	43293	12-12-73	4	UP	123	Two tows making bend not sure of each others intentions.
C10	20334	07-10-71	2	UP	123	Westbound tow talked to grounded tow, proceeded, colliding with towboat helping grounded tow get loose.

MILE SEGMENT 120 (115-125)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C11	51624	09-14-74	2	DN	120	Two tows approaching bend supposedly called for traffic ahead with no reply. They met, unaware of each other until too late.
C12	42120	12-22-72	2	UP	120	Tows meeting in bend; one tow had problem with electrical steering system.
C13	61791	03-08-75	1	UP	118	Two tug boats pulling rig. Tow makes passing agreement with tugs, but rig grounded and swung into path of overtaking tow.
C14	21552	02-23-72	2	DN	117	Tows meeting. Coupling broke between barges of eastbound tow, pushing barge into other tow.

MILE SEGMENT 170 (165-175)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	31009	10-11-72	4	DN	170.4	Tow loses power, rams bridge fender.
R2	42362	02-26-74	2	UP	170.4	Tow caught in suction, rams bridge fender.
R3	20588	09-03-71	1	DN	170.4	Tow caught in wash of other vessel, rams bridge fender.
R4	42388	10-09-73	4	UP	170.5	Tow hit barges moored in bend.
R5	43224	01-25-74	2	UP	170.5	Tow hit unlit moored barges in bend.
G1	20304	08-18-71	4	DN	173.2	Backed into bank while holding for oncoming traffic.
G2	20535	09-26-71	4	DN	173.9	Tow entered bend too fast.
G3	51698	10-13-74	5	DN	173.9	Tow hit side of channel in bend.
G4	21715	01-15-72	3	DN	173.9	Tow ran aground in bend.
G5	41288	09-03-73	3	DN	173.9	Tow hit side of channel in bend.
G6	53096	12-15-74	4	DN	173.9	Avoiding collision in bend, vessel grounded.
G7	22055	04-28-72	4	DN	173.7	Operator failed to position tow correctly in bend.

MILE SEGMENT 170 (165-175)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C1	51402	10-24-74	3	UP	168.7	Tow broke coupling wire; barge blocked canal for oncoming traffic.
C2	50882	06-13-74	2	UP	168.7	Tow lost steering, veered into oncoming barge.
C3	43271	01-24-74	4	UP	170.4	Pilot misjudged available width of channel in congested passing situation.
C4	31821	07-03-72	4	UP	172.7	Operators failed to use caution in navigating blind bend.
C5	63812	12-05-75	3	DN	170.5	Operator failed to navigate with caution in bend.
C6	53022	10-10-74	4	DN	168	Tow passing tow in fog drifted and struck other tow.

MILE SEGMENT 240 (235-245)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	50832	09-03-74	3	UP	238.4	Two tows in lock. The first tow was already moored, the second was getting into place. The second tow ran into the back of the moored tow.
R2	41441	10-25-73	7	DN	237.9	Tow lines between barges had been damaged prior to passing bridge. Lines slackened and affected steering ability. Barge hit bridge.
R3	20144	06-21-71	3	UP	243.6	Tow hit bridge.
R4	21572	12-17-71	1	UP	243.6	Tow was backing down to wait for tow going in other direction to pass bridge. It hit bridge fender.
R5	22052	06-11-72	4	UP	243.6	Tow negotiating bridge. Wind affected his lead light barge, causing it to hit bridge fender.
R6	22054	04-20-72	3	DN	238.6	Tow waiting to enter locks. Engines failed; wind pushed tow into wall.
R7	41926	01-11-75	4	UP		
					238.6	Tow leaving locks. Current pushed him into dolphin.
R8	31806	01-21-73	3	UP		
					239.9	Tow was affected by strong wind while navigating along starboard side of channel. Hit navigation light.

MILE SEGMENT 240 (235-245)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
G1	41291	12-29-73	6	DN	244.1	Tow was making a bend. Operator misjudged tide, hitting bank.
G2	20842	09-05-71	4	DN	244.1	Tow was overtaking other tow. They came to bend before he had completed the passing. To avoid hitting other tow he grounded.
G3	63208	03-30-76	1	UP	236.9	Tow grounded intentionally while waiting for lock to open. When trying to get underway found that tow was fast aground. Damaged tow trying to free it.
C1	53148	05-13-75	7	UP	243.8	Tow pushing 7 barges with no lookout overran tow in front of him.
C2	32520	04-12-73	2	DN	238	Two tows meeting. Passing agreement made. One tow was affected by bank suction, sheering into other tow.
C3	60199	03-07-75	2	DN	239.9	Two tows meeting in bend. No passing agreement. One tow did not stay on his side of channel.
C4	60895	11-13-75	3	DN	239	Two tows on opposite sides of bank waiting to go through lock. When lock opened the rush of water caused one tow to drift into channel. While trying to maneuver drifting tow, steering went out and he went across channel into other tow.

MILE SEGMENT 240 (235-245)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C5	61912	03-08-76	2	DN	235.2	Two tows meeting in bend. One tow was affected by low water and bank suction; couldn't make bend correctly.
C6	62383	05-23-76	4	UP	241	Two tows meeting at intersection of river & ICW. Passing agreement made. One tow couldn't keep on his side due to current.
C7	62124	04-24-76	2	DN	243.7	Tow/barges meeting tow/dredge. Wind caused tow/dredge to lose control when slowing down, blowing dredge into oncoming tow.
C8	64074	08-16-76	UNK	UP	236	Tow getting underway. Bank suction caused vessel to swing across channel into eastbound tow.

MILE SEGMENT 280 (275-285)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	50564	09-13-74	2	UNK	276.5	While maneuvering, rammed canal light #65.
R2	52016	03-17-75	4	DN	277.1	Wind pushed light barges into dock.
R3	52226	03-10-75	2	DN	280	Barge rammed moored unlit barges in fog.
G1	41495	11-14-73	2	DN	276.5	Crowded starboard side of channel. Grounded with subsequent loss of two vessels.
G2	30872	08-05-72	7	DOCKING	276.3(?)	Grounding and possible ramming of underwater object.
G3	42097	05-26-73	2	UP	275.4	PIC mistook old river cove for GIWW and grounded vessel.
C1	60691	09-05-75	4	DN	276.1	Failure to compensate for current led to loss of control.
C2	20642	11-05-71	2	UP	281	Steering failure due to generator breakdown.

MILE SEGMENT 280 (275-285)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
C3	21068	12-21-75	2	UP	282.4	Barge on wrong side of channel in fog rammed by freighter.
C4	30400	07-01-72	1	DN	280	Barges collided; communications failure.
C5	51506	12-31-74	2	UP	277.2	Barges collided in fog; communications failure.

MILE SEGMENT 400 (395-405)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	63135	04-18-76	UNK	DN	400.7	Current and wind pushed barge into north side of east rivergate.
R2	63137	09-14-75	UNK	UP	400.9	Wind set barge against north side of west rivergate.
R3	63121	05-30-75	2	UNK	400.9	Current and wind pushed barges into north side of west rivergate.
R4	63]22	07-12-75	UNK	DN	40C.7	Current pushed barges into north side of east rivergate.
R5	63127	04-17-76	UNK	DN	400.7	Current set tow into north side of east rivergate.
R6	63128	05-16-76	UNK	DN	400.7	Current set tow into east rivergate (north side?)
R7	63129	06-02-75	2	UP	400.9	Wind and current set tow into south side of west rivergate.
R8	63130	06-12-76	UNK	DN	400.7	Current set bow thruster into north side of east rivergate.
R9	20524	07-21-71	5	UNK	(400.7?)	Current and wind set barges into rivergate.

MILE SEGMENT 400 (395-405)

GULF INTRACOASTAL WATERWAY - WEST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R10	20455	08-11-71	3	DN	400.7	Sun on horizon led to misjudgment on alignment. Struck south side of east rivergate.
R11	50549	09-17-74	1	UP	405	Action taken to avoid disabled outboard craft led to ramming moored barge.
R12	63117	09-07-75	UNK	UP	400.9	Crosswind affected tow. Tow hit floodgate wall.

MILE SEGMENT (125-135)
GULF INTRACOASTAL WATERWAY - EAST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R1	63947	11-21-75	1	UNK	127.8	Boom of derrick tow hit raised bridge. Daupin Island Bridge.
R2	63949	11-20-75	3	UNK	127.8	High winds and currents caused tow to hit bridge - Dauphin Island Bridge.
R3	63943	04-15-76	12	UNK	128.5	Strong cross current and strong winds forced tow into buoy and beacon near Dauphin Island Bridge.
R4	62929	01-28-76	2	UNK	128	Hit Dauphin Island Bridge. CG says due to wind and current. Master says buoy out of place.
R5	60404	05-04-76	2	UNK	128	Hit Dauphin Island Bridge due to strong winds and current.
R6	53158	02-22-75	UNK	UNK	128	Strong winds and currents. Hit Dauphin Island Bridge.
R7	50099	06-24-74	6	UNK	128	Strong winds and tide. Hit Dauphin Island Bridge.

MILE SEGMENT (125-135)

GULF INTRACOASTAL WATERWAY - EAST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
R8	53016	04-04-75	4	UNK	127.8	Strong winds and tide. Hit Dauphin Island Bridge.
G1	63946	01-02-76	2	UNK	127.8	Strong wind grounded tow near Dauphin Island Bridge.
G2	63931	06-28-76	2	UNK	127.8	Tow grounded and swung into bridge.
G3	62937	03-25-76	2	UNK	128	Strong current caused tow to ground.
G4	63026	01-02-76	4	UNK	127	Grounded in strong current.
G5	63096	04-18-76	2	UNK	127	Grounded on edge of channel.
G6	63001	03-22-76	13	UNK	127	Strong wind and tide grounded tow near Dauphin Island Bridge.
G7	62934	02-05-76	UNK	UNK	127	Moved over to let tow pass and grounded on edge of channel.
G8	62646	01-24-76	3	UNK	127	Strong winds blew light tow aground on edge of channel.
G9	62112	01-19-76	2	UNK	127	Strong winds and tide forced tow aground on edge of channel.
G10	62113	03-13-76	2	UNK	127	Intentionally grounded to wait out fog.

MILE SEGMENT (125-135)

GULF INTRACOASTAL WATERWAY - EAST

CODE	CASE NUMBER	DATE	NO. OF BARGES	DIRECTION	MILE POINT	COMMENTS
G11	62190	01-22-76	1	UNK	128	Grounded in strong current.
G12	62216	02-25-76	3	UNK	129	Grounded in unmarked channel.
G13	21375	02-22-74	4	UNK	132.5	Grounded in channel.
G14	42242	03-31-74	2	UNK	127	Grounded. Light tow. High winds.
G15	32101	10-24-72	UNK	UNK	133	Grounded. Bank suction.

APPENDIX D

CORRESPONDENCE WITH TOWBOAT OPERATORS AND TRANSCRIPT OF INFORMATION FROM TOWBOAT PERSONNEL

Five towboat operating companies agreed to assist the study by arranging for captains or pilots with their organizations to talk with study team personnel. A sample letter follows which was used to explain the study objectives, describe the kinds of information desired, and describe procedures. A similar letter was sent to each company. Following the sample letter, a transcript is provided of information from our conversations with operating personnel.

Systems Analysts for Engineers, Economists and Environmental Scientists

ECO

ENGINEERING COMPUTER OPTECNOMICS, INC.

August 15, 1978

Mr. Larry Hays
Ohio Barge Line
Box 126
Dravosburg, Pennsylvania 15034

Dear Mr. Hays:

This letter is a follow-up to the telephone conversation which I had with Bill Porter of your office concerning a research project being conducted for the United States Coast Guard. Mr. Porter, in turn, suggested that I correspond directly with you.

As I explained to Mr. Porter, our ongoing effort is a study of the human and physical factors affecting the occurrence of towboat collisions, rammings, and groundings on the Western Rivers and Gulf Intracoastal Waterway of the United States. More specifically, we are analyzing Coast Guard accident reports of towboat collision, ramming and grounding incidents on those waterways in order to detect any consistent patterns of causal factors and to gain further insight concerning the extent that human factors are involved in these incidents.

From what we have completed thus far, it appears that a significant portion of the incidents occur within some 40-odd ten mile segments along the various rivers, and more precisely tend to occur at certain discrete locations within those segments. At these locations, we have attempted to define as many peripheral relationships as possible, such as human engineering, tow characteristics, waterway characteristics, river conditions, navigation aids, traffic density, obstructions, etc., with the intent of looking for commonalities or disparities from one site to the next where these accidents tend to occur with more frequency than at those sites which exhibit a lesser frequency of occurrence of accidents.

In accordance with our conversation with Mr. Porter, we have enclosed a series of chartlets depicting those sites with high frequencies of occurrence of collisions, rammings, and groundings, and, moreover, have indicated the location of those incidents which occurred during FY 1972 to FY 1976. All incidents

ECO

Mr. Larry Hays
Ohio Barge Line
August 15, 1978
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are coded for purposes of anonymity on each chartlet according to explanation sheets attached to them. Our intent in sending these chartlets to you is to have some of your operating towboat captains and pilots review them and offer their comments as to any consistent pattern of causal factors that they might perceive to be present at these locations, and, secondly, the human factor aspects of these accident scenarios in regard to the control function as it relates to the towboat and its barges, the navigation function as it relates to the waterway, the navigation aids, and other physical factors, and the perception function as it relates to such items as traffic, visibility, and other environmental factors.

What we propose to do is, with your approval and direction, speak to these captains and pilots directly via the telephone and integrate their comments within our overall analysis. No comments will be quoted and, as throughout this effort, anonymity will be preserved.

Finally, as I mentioned to Mr. Porter in our conversation, we would very much like to conduct our conversations with the captains and pilots you designate at times and places to their convenience, but due to contractual obligation would very much appreciate completing this discussion process by September 6th.

Your willingness to participate in this very important aspect of safety research is appreciated by both ourselves and the United States Coast Guard.

Yours truly,

Richard M. Willis

W:w
Encls.

COMMENTS BY OPERATING PERSONNEL

Pilot information will be presented here in narrative format. This information has been edited and organized by ORI. However, all comments concerning operation, environment, structures, currents, etc., are those of the pilots and captains.

UPPER MISSISSIPPI RIVER

Mile segments 40 and 50 (35-55) contain two bridges: The Cape Girardeau Highway Bridge at mile 51.6 and the Thebes Railroad Bridge at mile 43.7. There are few accidents at the highway bridge, but the railroad bridge, with the bend just above it at mile 46, does present a problem. There are rocks on both sides of the bend, and the current forces tows toward the left descending shore when proceeding downriver. Most accidents happen during downbound passages.

Just above the bridge the current is relatively steady and parallel with the bank. As the tow gets closer to the bridge, at about mile 44.3, the current divides because of a bend at the bridge. One branch of the current hugs the left descending shore, and one branch crosses the river toward the right descending shore. Tows must approach the bridge on an angle to counteract the set of the current. In addition, they must steer around the bend at the bridge which causes a slide toward the right descending shore and in the direction of the current.

Three dikes have been installed above the bridge, and one below, which do not appear on charts.

Below the bridge there is a relatively narrow channel lined with rocks on both sides.

Tows have difficulty because of forces of current and wind and shallow water hydrodynamic forces. The towboat has limited instrumentation (radar, turn indicator, and depth finder) to operate in this environment. Instrumentation for displaying speed through the water and speed over the ground would be useful for determining stopping distance.

Rule-of-thumb for determining maximum number of barges per towboat is 200 hp per loaded 1500 ton barge or 100 hp per empty.

On the Upper Mississippi, at Lock 26, tows proceeding upriver encounter strong cross currents which set head of tow to starboard on the guide wall. This lock cannot be approached like other locks because of cross currents, which are stronger during high water. Pilots using Lock 26 for the first time often get into trouble.

The lock is built into a pocket along the shore, and there is an outdraft on the upstream side. Downbound tows must take care, or this outdraft will sweep them out of the pocket and into the river. During high water, most companies provide the services of a tug to help the operator hold his tow in the pocket and against the guide wall. Tug assistance is also needed during ice conditions.

OHIO RIVER

At Lock 50, Ohio River, an eddy current exists below the dam, extending 200 to 400 feet below the guide wall. Eddy currents are stronger during high water. Eddy currents cause cross currents perpendicular to shore, which tend to rotate the tow. Cross currents are not as bad when the pool is normal.

Lock 52 is a wicket type dam which consists of gates hinged at the bottom of the river. A gate called a "bear trap" is positioned on the side of the river opposite the lock. The bear trap is used to adjust the river level, and a large quantity of water passes through the bear trap. The combination of high current on one side of the river and slack water behind the lock creates the eddy and an updraft or water running toward the lock.

The exact location of the eddy varies with river stage and how the lock master regulates the flow over the dam and through the bear trap. As the tow

approaches the lock, the pilot radios ahead for information on the gage and how much water is running.

The strength of the eddy can be controlled by the lockmaster. If he drops several wickets on the lock side, the increased current flow will destroy the eddy. This is done on some occasions, but it is not clear why the eddy is not always controlled.

When the river reaches a certain height, the wickets can be dropped and, after the river level stabilizes, tows will pass over the dam in both directions.

The wicket type dam is a low-lift dam, and tows must use the lock chamber of "high-lift" dams at all river stages.

When operating downstream the current flow tends to pull the tow toward the bear trap because of the large quantity of water flowing through the bear trap, creating a funneling effect on the upstream side.

Both directions have their problems, but the more difficult approach is downstream loaded during high water.

Each lock has its own characteristics. The worst lock is the Gallopolis Lock. It carries the most tonnage on the river. It is a high-lift dam and is so congested that tows must wait sometimes 2.days to lock through. There are cross currents on the upstream side and eddies below. It is more difficult to get into the upstream side of this lock.

Approaching the Gallopolis from upriver is also a problem since the lock is constructed at an angle to normal current flow. As the tow approaches from upstream, it cannot line up with the lock or the current will catch the stern and sweep it out into the river. The pilot must flank into position and hold the stern next to the bank until the head of the tow is near the lock entrance. Then he ties off the stern and steers the head around into the lock.

GULF INTRACOASTAL WATERWAY WEST

A bridge is currently being constructed at mile 238, which obstructs the entrance to Calcasieu Lock. The bridge is located on the east side of the lock and is so close to it that when the head of a tow reaches lock, the stern is still not clear of the bridge. This arrangement has accounted for many accidents during the construction period.

The closeness of the bridge restricts maneuvering room when entering the lock. Beam winds from the Gulf make westbound tows with empty barges difficult to control. Many tows ram the construction area at the bridge. The Coast Guard should have investigated the effect this bridge would have on marine traffic before the site was chosen.

A guide wall is suggested to run from the bridge piers to the lock, about 1000 feet, so that tows could land against it before entering the lock.

ILLINOIS WATERWAY

Mile 293.1, Butterfly Dam, is in the middle of the Chicago Sanitary and Ship Canal. The canal is lined with rock walls and barges tied off on both sides of the canal. The canal width is 150 feet, and tows must pass through at dead slow speed to avoid moored barges.

At Lemont, mile 300.5, the wind is a big problem. The Lemont Highway Bridge is narrow, and barges are tied up on both sides of canal. A towboat must have a retractable pilot house to pass under bridge, and vision is restricted. It is delicate work passing between strings of moored barges, and collisions often occur.

Mile 43.1, Pearl Bridge, is one of the real problem areas on the Illinois River. The bridge is built on a point, or bend, in the river. The bridge is too narrow. Waters are shallow, and both wind and currents cause serious problems for southbound tows.

Northbound tows must flip around to make the bridge, and wide tows often rub bridge protection.

Rule-of-thumb on tonnage. Presently operating with 25,000 tons and 4100 hp, which is comfortable. This works out to 6.1 tons per hp.

Low hp boats are a nuisance because they can't make time upriver against the current and hold up both upbound and downbound tows.

APPENDIX E
CORRESPONDENCE WITH INSURERS

Five marine insurers assisted the study by providing information about actual damage costs resulting from towboat accidents. An example copy of the correspondence with the insurers follows.

Systems Analysts for Engineers, Economists and Environmental Scientists

ECO

ENGINEERING COMPUTER OPTECNOMICS, INC.

June 13, 1978

Mr. Charles Ruland
Marine Office of America Corporation
360 W. Jackson Boulevard
Chicago, Illinois 60606

Dear Mr. Ruland:

As discussed in our recent telephone conversation, our company, Engineering Computer Optecnomics, Inc. (ECO), and Operations Research, Inc. (ORI) are under contract to the U.S. Coast Guard to study human and physical factors affecting collisions, rammings, and groundings on the Western Rivers and Gulf Intracoastal Waterway. The research program is a segment of a broad guaged program aimed at the reduction of marine casualties through increased understanding of the variables affecting marine safety. Within the general research program, a major task is to evaluate the value of the estimate of vessel damage that is contained in the Coast Guard's accident reports (CG-2692) by comparing that "estimate" with the actual repair cost as obtained from various insurance companies.

We have identified approximately 60 towboat casualties occurring between 1972 and 1976, which resulted in substantial damage. We are asking that you examine the enclosed list of towboat casualties, especially the dollar damage as contained in the last column, and give us your opinion with respect to the accuracy of the Coast Guard's estimate. In order to simplify the task for you we have included two copies of the towboat casualties so that you can make your handwritten comments directly on the second copy.

LCDR Larry Olsen, Office of Research and Development, Coast Guard Headquarters in Washington, D.C., is the Coast Guard project officer for this contract. LCDR Olsen can be reached at (202)-426-1058.

It has been requested that this segment of the research program be completed by June 30, 1978; however, if you feel that you require an additional two weeks, please contact my associate, Mr. Virgil Keith, or myself here at ECO and we will make every effort to obtain the additional time for you.

Mr. Charles Ruland
Marine Office of America Corporation
June 13, 1978
Page 2

On behalf of the U.S. Coast Guard, ORI, and ourselves, may I thank you for your continuing interest in reducing marine casualties and for your cooperation in this program.

Very truly yours,

Richard M. Willis

W:w
Encls: List of towboat casualties (2)

FY 1972

CASE NUMBER	CASUALTY DATE	VESSEL NAME	OFFICIAL NUMBER	HOME PORT	OWNER OR AGENT	CASUALTY LOCATION	VESSEL TYPE	DAMAGE
20141	3/22/70	TUG PAULA	276368	New Orleans, Louisiana	Frederick J. Bowers, 828 Carmadelle Marrero, Louisiana 70072	GIWW near Dauphin Island Alabama	Tug	$ 36,000
20347	7/12/71	ROSE TRANCHITA	522413	Milwaukee, Wisconsin	Wisconsin Barge Line, Inc. Cassville, Wiscosin 53806	UMR, Fort Madison Highway Bridge	Towboat	300
20475	9/12/71	CAP'N ED	226733	Pensacola, Florida	Brown Marine Service, Inc. P.O. Box 1415 Pensacola, Florida 32502	GIWW Mile 150	Tug	30,000
20655	10/26/71	AETNA-LOUISVILLE	262724	Louisville, Kentucky	Ashland Oil Inc. 1409 Winchester Avenue Ashland, Kentucky 41101	Ohio River Mile 647.8	Towboat	1,000
21068	12/21/71	L.Z. WALKER	287074	Houston, Texas	Windward Transportation Company 1818 McKinney Avenue Houston, Texas 17003	GIWW Mile 284 WHL, Sabine-Neches Canal	Towboat	5,000
21071	12/27/71	MARY E	297454	Lake Charles, Louisiana	Lake Charles, Towing Co. P.O. Box 951 Lake Charles, Louisiana 70601	Atchafalaya River Mile 111	Towboat	30,000
21264	12/19/71	EMMA V.	266269	Louisville, Kentucky	Igert Towing Co., Inc. P.O. Box 606 Paducah, Kentucky 42001	Tennessee River Mile 414.4 Louisville & Nashville Railroad Bridge	Towboat	30,025
21355	2/29/72	W.P. JACKSON	262737	Pittsburgh, Pennsylvania	Thomas Marine Company 56 Sexton Road McKees Rocks, Pennsylvania 15136	Mississippi River Mile 475.7	Towboat	250,000
21824	4/28/72	ESSO W. VIRGINIA	289724	Wilmington, Delaware	Humble Oil & Refining Co. P.O. Box 411 Baton Rouge, Louisiana 70821	Ohio River Mile 279.2	Towboat	600
21991	2/08/72	SHERRY GENE	517373	New Orleans, Louisiana	Sherry Gene Towing Inc. Route 1, Box 625 Merrero, Louisiana	GIWW Mile 263	Tug	50,000
22093	3/17/72	HARD WORK	502021	Houston, Texas	Alamo Barge Lines 900 Houston Natural Gas Building Houston, Texas	Mississippi River Goodhope, Louisiana	Towboat	350,000

CASE NUMBER	CASUALTY DATE	VESSEL NAME	OFFICIAL NO.	HOME PORT	OWNER OR AGENT	CASUALTY LOCATION	VESSEL TYPE	DAMAGE
22114	3/27/72	AMERICAN BEAUTY	513017	Wilmington, Delaware	Rose Barge Lines, Inc. 222 S. Central Avenue St. Louis, Missouri	Mississippi River Helena Highway Bridge	Pushboat	$ 2,800
22147	5/26/72	MORGAN CITY	273580	Port Arthur, Texas	Clary Towing Company, Incorporated Route 2 Box 89 Orange, Texas 77630	GIWW Mile 286 WHL	Towboat	60,000
22281	1/09/72	CAPT. KELLEY	296592	New Orleans, Louisiana	Kelley Boat Company, Incorporated P.O. Box 331 Belle Chase, Louisiana 70037	Mississippi, River Pilottown, Louisiana	Towboat	30,000
22364	4/20/72	THOMAS W. HINES	263149	Louisville, Kentucky	Hines, Incorporated P.O. Box 840 Bowling Green, Kentucky 42101	Ohio River Mile 720.7 Cannelton Lock & Dam	Towboat	16,000
22381	5/03/72	YETTA ALTER	262510	Chicago, Illinois	Alter Company P.O. Box 3708 2333 Rockingham Road Davenport Iowa	Hannibal Railroad 309.9 UMR Bridge	Pushboat	30,000

CASE NO.	CASUALTY DATE	VESSEL NAME	OFFICIAL NUMBER	HOME PORT	OWNER/AGENT	CASUALTY LOCATION	VESSEL TYPE	DAMAGE
30752	6/1/72	NEW MEXICO	284955	New Orleans, Louisianna	Defilece Enterprises, Inc. PO Box 135 Met., Louisianna	Atchataluya River No. 4 Buoy	Tug	$ 30,000
31489	12/13/72	BLACK SHEEP	284208	Mobile, Alabama	Dick Meyers Towing Service Inc., PO Box 6237 Mobile, Alabama	Mississippi River New Orleans Harbor	Tug	50,000
31506	12/5/72	GRAND BEACH	279842	Chicago, Illinois	Gust K. Newberg Constr. Co. 2040 N. Ashland Avenue Chicago, Illinois 60614	Ohio River Mi. 843 Uniontown L&D	Harbor Boat	30.000
31931	11/7/72	RAY A	261413	Milwaukee, Wisconsin	Wisconsin Barge Line Inc. Cassville, Wisconsin 53806	Upper Mississippi River Mi. 384	Towboat	25,000
32096	3/13/73	WARREN HOUGLAND	237492	Louisville, Kentucky	Hougland Barge Line, Inc. 1231 South 3rd St. Paducah, Kentucky 42001	Lower Mississippi River Mi. 412	Towboat	325,000
32132	12/1/72	WISCONSIN	262467	Mobile, Alabama	Findlay Towing Co., Inc. PO Box 2117 Tuscaloosa, Alabama 35401	Warrior River Mi. 329	Towboat	40,000
32316	1/18/73	WILLIAM S. SMITH	251737	New Orleans, Louisianna	Crescent Towing & Salvage Company, Inc. New Orleans, Louisianna	Houston Ship Channel	Tugboat	500-1000
32597	2/28/73	DAD III	528-598	Houma, Louisianna	Doucet & Adams, Inc. PO Box 81 Galliano, Louisianna 70354	Berwick Bay Oil Co. Dock Berwick, Louisianna	Tugboat	6,050
32602	11/12/72	POINT CHICOT	225257	Wilmington, Delaware	Nilo Barge Line, Inc. 112 4th St. St. Louis, Missouri 63102	Southwest Passage Mississippi River Gulf of Mexico	Diesel Tug	3,000
32661	5/15/73	JA BISSO	209464	New Orleans, Louisianna	En Bisso & Son 285 Walnut Street New Orleans, Louisianna	General Anchorage New Orleans, Louisianna	Towing	8,000
32666	5/15/73	MATE	518372	Houma, Louisianna	Marine Towing Co., Inc. 601 Little Farms Ave. New Orleans, Louisianna	Mississippi River Absam Industry Canal Forebay	Towing	50,000
32983	2/13/73	BEN McCOOL	270809	Greenville, Mississippi	Greenville Towing PO Box 690 Greenville, Mississippi 38701	Mi. 461 LMR	Towboat	40,000

FY 1974

CASE NO.	CASUALTY DATE	VESSEL NAME	OFFICIAL NUMBER	HOME PORT	OWNER/AGENT	CASUALTY LOCATION	VESSEL TYPE	DAMAGE
40310	7/5/73	CAP'N ED	226733	Pensacola, Florida	Brown Towing PO Box 1415 Pensacola, Florida 32502	¼ Mi. South of Industrial Fore-bay and Mississippi River	Towing	$ 20,000
40481	3/9/73	KATHRYN ECKSTEIN	512902	Milwaukee, Wisconsin	Wisconsin Barge Line Cassville, Wisconsin	Mi. 595 LMR	Towboat	4,000
40645	8/20/73	R.H. VAUGHAN	505517	Baton Rouge, Louisianna	Louisianna Department of Highways 4245 Capt. Sta. Baton Rouge, Louisianna	Bayou Dularge Bridge (Intra. Coastal) Houma, Louisianna	Tugboat	34,700
41207	7/15/73	NORTH STAR	284238	Chicago, Illinois	NC Twin City Barge & Towing 1303 Red Rock Rd. St. Paul, Minnesota 55101	Mi. 445.8 Tennesee River	Towing	250,000
41495	11/14/73	CORPUS CHRISTI	275125	Corpus Christi, Texas	Stellman Transportation Co. PO Box 1111 Aransas Pass, Texas 78336	29° 57' 54" N 93° 51' 19" W	Towing	108,000
41832	1/25/74	GLENN T. II	529037	Morgan City, Louisianna	Berwier Bay Oil Co. PO Box 2708 Morgan City, Louisianna 70380	Morgan City Louisianna Railroad Bridge	Tug	200,000
42202	10/15/73	BAROID 110	512635	New Orleans, Louisianna	NL Industries Inc. PO BOX 26306 New Orleans, Louisianna	Gentilly Bridge Across Indus. Canal, Port of New Orleans	Towing	30,000
42714	5/2/74	STANTON K. SMITH	264651	Sheffield, Alabama	Arrow Transp. Co. 221 N. Columbia Ave. Sheffield, Alabama	Mi. 2734 UMR, L7Dam #24	Towboat	50,000
43016	3/28/74	MARK M.	279667	Louisville, Kentucky	Mardie Boggs & Son PO Box 363 Catlettsburg, Kentucky 41129	Mi. 317.6 LDB Ohio River, Boggs Landing	Towboat	13,000
43046	7/20/73	MAMA LERE	264863	Greenville, Mississippi	Valley Towing Service PO Box 1079 Greenville, Mississippi 38701	Mi. 561 LMR	Towboat	45,000
43266	4/6/74	[illegible] EXPRESS	544911	New Orleans, Louisianna	Spanier Marine Corp. PO Box 378 Harvey, Louisianna 70058	Mi. 222 AHP	Towboat	15,000

FY 197[illegible]

[illegible]	CASUALTY DATE	VESSEL NAME	OFFICIAL NUMBER	HOME PORT	OWNER/AGENT	CASUALTY LOCATION	VESSEL TYPE	DAMAGE
[illegible]	[illegible]/74	LORELEI C.	283090	Houma, Louisiana	Crenel Towing Box 0493 Lafitte, Louisiana	Harvey Canal Lock New Orleans, Louisiana	Towboat	4700
[illegible]	[illegible]/74	PAUL LAMBERT	500950	St. Paul, Minnesota	Twin City Barge & Towing 1303 Red Rock Road St. Paul, Minnesota 55165	Mi. 814 UMR	Towboat	1500
[illegible]	8/3/74	HOLLIE ANN	540937	Port Arthur, Texas	Anchor Towing Inc. 2011 Dupont Dr. Orange, Texas	Calcasion Locks Intercoastal Canal	Towboat	3800
51730	1/16/75	DIXIE STAR	266230	Wilmington, Delaware	Dixie Carriers Box 248 Harvey, Louisiana 70058	Mi. 389 LMR	Towboat	10,000
51822	2/20/75	CITY OF GREENWOOD	276871	Minneapolis, Minnesota	Richard's Towing Port Richards Savage, Minnesota	Mi. 692 LMR	Oil Screw	10,000
52192	2/18/75	EDEN BRENT	286881	Greenville, Mississippi	Brent Towing Co. PO Drawer B Greenville, Mississippi	Melville, Louisiana Atcholaya River	Oil Screw	30,000
52250	2/26/75	T. M. NORSWORTHY	262534	Houston, Texas	Houston Barge Line Box 1277 Houston, Texas 77001	Mi. 636 Ohio River	Tugboat	13,275
52394	4/5/75	LARRAYNE ANDRESS	516188	Greenville, Mississippi	Big Valley Towing Inc. Box 235 Greenville, Mississippi 38701	Mi. 130 AHP, MR	Tugboat	5000
52458	1/23/75	DANIEL WEBSTER	280062	Wilmington, Delaware	Union Meshling Corp. One Alice Plaza Pittsburgh, Pennsylvania	Mi. 13-1 UMR	Tugboat	13,000
52652	2/25/75	GAYLEANN	506544	New Orleans, Louisiana	Clem Perrin Marine Towing 204 Huey P. Long Ave. Gretna, Louisiana	Mi. 98.3 MR Perry St. Wharf	Pushboat	75,000
52665	4/7/75	MARIE HENDERICK	534004	Milwaukee, Wisconsin	Wisconsin Barge Line Cassville, Wisconsin 53806	Mi. 531.3 LMR, Greenville Hwy. Bridge	Towboat	5000
52823	4/23/75	SEA OTTER	251285	Jacksonville, Florida	Claude O. Boss Jr. Inc. 3320 Kallel Drive Algiers, Louisiana	Mi. 189 WHL GI WW	Towing	136,000

FY 1976

CASE NUMBER	CASUALTY DATE	VESSEL NAME	OFFICIAL NAME	HOME PORT	OWNER OR AGENT	CASUALTY LOCATION	VESSEL TYPE	DAMAGE
60431	6/27/75	AMY MORAN	546569	Wilmington, Delaware	Moran Towing of Texas Box 3816 Port Arthur, Texas	Calcusien River near Beacon 68	Towboat	$ 20,000
60863	10/06/75	IMOGENE IGERT	504956	Louisville, Kentucky	River Towing Company Box 606 Paducah, Kentucky	Big Sandy River and by Tennessee River Mile 67	Towboat	200,000
61915	1/06/76	CAPT. ED	226733	Pensacola, Florida	Brown Marine Service, Incorporated P.O. Box 1415 Pensacola, Florida 32596	GIWW Mile 155 EHL	Tug	2,000
62107	12/04/75	YAZOO	272679	Vickburg, Mississippi	Drake Towing Company, Incorporated 3900 Veterans Memorial Boulevard Metairie, Louisiana 70002	Mississippi River Mile 133.5	Towboat	1,000
62390	4/07/75	GOPHER II	291300	Fort Smith, Arkansas	MidWest Dredging Company 4609 Clayton Expressway East Port Smith, Arkansas 72901	Atchafalaya River Simmesport, Louisiana, Louisiana & Arkansas Railroad Bridge	Pushboat	50,000
62447	8/13/75	JENNIFER	567431	New Orleans, Louisiana	Charles Arnold Jennifer Marine Towing Inc. 601 Little Farms Avenue River Ridge, Louisiana 70123	14 Mileboard Inter-coasted Waterway	Pushboat	7,500
62541	12/06/75	HIAWATHA	544695	New Orleans, Louisiana	James Marine Service, Inc. 1210 Manson Drive Marrero, Louisiana 70072	Mile 94.4 MR	Pushboat	200
62609	12/06/75	POINT CLEAR	528945	New Orleans, Louisiana	Plimsoll Marine, Inc. 1810 BNO, 1010 Common St. New Orleans, Louisiana	Below 6 mile point MR	Towboat	5,000
62924	3/28/76	J. RUSSEL FLOWERS	568139	Greenville, Mississippi	Flowers Transportation, Incorporated Box 1588 Greenville, Mississippi 38701	Mile 179.2 UMR St. Louis, Missouri	Towboat	800
63484	9/27/76	DOLPHIN	260585	Houston, Texas	Alamo Barge Line 900 Houston National Gas Building Houston, Texas 77002	Mile 208 West GIWW, Louisiana	Towboat	75,000

*U.S. GOVERNMENT PRINTING OFFICE: 1979 629-044/2204

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F